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ART. I.—*On the first Hurricane of September* 1853, *in the Atlantic; with a Chart; and Notices of other Storms:* by W. C. REDFIELD.

SINCE I first ascertained the rotary and progressive movement of storms, in the year 1821, I have on various occasions endeavored to show some of the results which then became obvious or have been established in the progress of more extended investigations.* Of the results thus noticed, the systematic rotation of storms and gales in different regions, their opposite rotation and polar progression on opposite sides of the equator, and the mechanical influence of their rotary action on the movements of the barometer, when viewed in their practical relations, are the most important.

On the present occasion, I propose to give some account of the progression and extent of the earliest autumnal hurricane of 1853 in the north Atlantic. This case is not selected as differing in its essential features from other gales in the same region, but chiefly on account of the unusual extent of route that can be traced by direct observations. For it seems to have been inferred by some, that those gales which have previously been traced and

* See this Journal, vols. xx, xxv, xxxi, xxxv, and xlii, First Series; and vols. i and ii, New Series: with other communications. For further elucidations in this department of meteorology, since the year 1837, see the valuable publications of Col. Reid, Mr. Piddington, Surgeon Thom, and other writers.

their routes shown on our storm-charts, must have originated at or near the places where our first observations were obtained. It is obvious, however, that such inferences are quite erroneous.

It is not deemed necessary in this stage of the inquiry, to give such extensive elucidations of the rotation and geographical relations of the storm-wind as I have shown in the case of the Cuba hurricane of Oct. 1844.* I shall therefore only adduce in concise form such marine reports and observed phenomena as will serve to show the continued cyclonic violence, progress, and extension of the gale.

In submitting the reports by which its general route is established we shall follow the path of the gale westwardly, from off the Cape Verde Islands, crossing the Atlantic to the vicinity of Cape Hatteras, on the American coast, and from thence, on its recurvated course through the higher latitudes of the Atlantic, in the direction of the Spitzbergen sea, and touching, in its vast extension, the western shores of the British Islands.

1. The barque *William Money*, from Bombay, experienced heavy weather, with shifting winds, Aug. 30th and 31st, in lat. 13° N., lon. 29° W., with apparently worse weather in the vicinity.

2. *Independence*, from Talcahuano, Sept. 1st, in lat. 15° 40′, lon. 48° 20′, a violent hurricane, beginning at N. E. and ending at E. S. E.; lost all three topmasts.

3. *Sea*, dismasted in the gale, Sept. 2d, lat. 16° N., lon. 50° 30′ W.

4. *Warwich*, Sept. 3d, severe hurricane, lat. 16°, lon. 51° W.; vessel damaged.

5. *Hermann*, Sept. 3d, lat. 20°, lon. 56° W., severe gale 12 hours: barometer falling as low as 27·30 in. Four other vessels dismasted in this vicinity were reported from one of the Windward Islands; where some heavy weather was experienced at this time. [See note, p. 10.]

6. *Sylphide*, Sept. 3d, lat. 22° 29′, lon. 63°, hurricane; lost topmast, deck load, &c. Two other vessels dismasted Sept. 3d arrived at Havana.

7. *Arve*, night of Sept. 3d, in lat. 22° 30′, lon. 63° 50′, hurricane; disabled and abandoned.

8. *Ocean Bird*, Sept. 4th, [civil time] at 4 P. M. gale increasing from east, with heavy swell, steering south, under double reefed topsails, in lat. 27°, lon. 69°. At 10 P. M. full hurricane from E. N. E.; scudded under bare poles; wind gradually veering round by the north, during the night; hardest gusts from westward; at 4 A. M. Sept. 5th, had got to S. S. W., and hurricane began to abate. During its continuance ran before it, through a curve of eighteen points of the compass.†

9. Brig *Commerce*, bound south, had the hurricane Sept. 5th, from N. E. to S. W., lat. 29° 30′, lon. 69° 50′; was hove on beam ends and dismasted.

* This Journal, vol. ii; 1846: New Series.

† From Capt. Atkinson: The barometer had fallen to 29·10 in the early part of the gale, but was not observed during the period of its greatest violence.

10. *Regatta*, Sept. 6th, lat 29° 20′, lon. 71°, hurricane; veering from N. E. to S. W.; split storm sails; main rail under water three hours; could not be heard four feet, with utmost effort of voice.

11. *Elena*, totally dismasted, Sept. 6th, lat. 32°, lon. 70°.

12. *J. Grierson*, for Gulf of Mexico, Sept. 6th, lat. 31°, lon. 74° 30′, heavy gale from N. N. E., hauling to S. W.; dismasted.——*Caroline*, crippled in heavy blow, Sept. 6th, and put back to Charleston.

13. *Flash*, Sept. 6th, lat. 33° 40′, lon. 76°, hurricane from N. E. to W.; damaged.

14. *Dione*, Sept. 6th, lat. 33° 15′, lon. 77° 20′, hurricane from E. N. E.; lost topsails, top-gallant-masts, &c.

15. *G. W. Lawrence*, Sept. 7th, lat. 33°, lon. 75°, dismasted in hurricane from E. N. E.

16. *Norfolk Packet*, hurricane, Sept. 7th, lat. 33° 50′, lon. 76° 20′; dismasted.

17. *Levant*, dismasted Sept. 7th, lat. 34° 10′, lon. 74° 10′, in a terrific gale from the eastward.——*John Adams*, dismasted in hurricane, 6th–7th of Sept. on south side of gulf stream.

18. *Viola*, dismasted in hurricane, Sept. 7th, near lat. 34° 16′, lon. 73°.

19. *Segesta*, Sept. 7th, lat. 34° 32′, lon. 72° 30′, hurricane, S. S. E. to N. N. W.; dismasted.

20. Steamship *Georgia*;* Sept. 6th, barometer at noon 29·85; lat. 38° 9′, lon. 73° 55′; wind southward, with a large heavy swell from southward and eastward, indicating a blow in that direction; during the night cloudy, with rain. Sept. 7th, [civil time] commences cloudy with fresh breezes from southward and eastward, and heavy cross swell: bar. at 1 A. M. 29·78, 4 A. M. 29·76, wind freshening to a gale: at 9 A. M. bar. 29·45, blowing heavy and sea rising. At noon bar. had descended to 29·10, wind still increasing and sea high; steamer's position about 80 miles E. of Cape. Hatteras; [lat. 35° 14′, lon. 74° 10′]; 1 P. M. bar. 28·40; blowing very heavy in squalls. At 2·30, moderating; 3 P. M. bar. 28·20, wind came out from northeastward, with exceeding heavy squalls; the sea-drift flew across the decks with great fury; no one could withstand its force; at 4 P. M. bar. 28·10, blowing harder than ever, and so continued till 6·30 P. M.; skylights and part of hurricane deck blown away; at 10 P. M. still blowing heavy and sea high: Midnight bar. 29 in., wind still subsiding; and at daylight on the 8th, had abated sufficiently to make sail; 8 A. M. weather moderating. Noon, lat. 35° 40′, lon. 72° 48′.

21. *Rescue*, Sept. 7th, lat. 36°, lon. 74° 30′, hurricane; dismasted.

22. *Albemarle*, capsized in the hurricane at midnight on the 7th, lat. 35° 30′, lon. 73°; all lost except one seaman.

23. *Lyra*, bound south, Sept. 7th, lat. 35° 50′, lon. 73° 30′, hurricane, from E. S. E. to W. N. W.; dismasted.

24. *Fanny*, Sept. 7th, lat. 35° 09′, lon. 71° 39′, hurricane, dismasted. ——*Algorna*, for the Chesapeake, dismasted in lat. —, lon. 70°. [Either the date or the latitude erroneously reported].

25. Brig *Swan*, Sept. 7th, [civil time] at noon, lat. 36° 26′, lon. 71° 44′, had reduced to short sail, gale S. E. by S., and high sea for last

* From reports and memoranda of Capt. Budd.

24 hours; standing south; 2 P. M. heavy gale; furled foresail and hove to; 4 P. M. gale increasing, furled topsail and scud before it under storm stay-sail, then bare poles; 6 P. M. hurricane, E. S. E.; broached to on port-tack; 7 P. M. wind truly terrific; thrown on beam-ends; dismasted about 9 P. M; barometer 28·85: [28·94 as compared with mine], at 11 P. M. force of hurricane began to abate, and before midnight gale had veered to E. N. E. At 4 A. M. Sept. 8th, gale N. N. E. moderating; 8 A. M. stiff breezes; noon, moderate; lat. 36° 13′, lon. 72° 40′.

26. *Star*, Sept. 7th, lat. 36° 10′, lon. 72°, hurricane, from N. E. to W.: dismasted.

27. *Addy Swift*, Sept. 6th, [civil time] fine weather, lat. 37° 20′, lon. 71° 30′, bar. 30·10 in., *a very heavy swell from S. E.*, gradually increasing; wind from S. W. to N. E. Sept. 7th, fine; light winds from N. E.; 8 A. M. bar. 30 in.; at noon, lat. 36° 30′, lon. 71°; wind S. S. E., a double reefed topsail breeze; western horizon very hazy; 2 P. M. cloudy, wind increasing; bar. 29·90; 5 P. M. sails furled, hove to under storm try-sail, gale S. S. E., slight rain, and tremendous sea running; bar. 29·50; [six hours from gale's center]. 7 P. M. severe hurricane from S. E.; at 8 P. M. vessel on her beam-ends, heading within five points of the wind; remained in this position until 10 P. M., when I cut away the mast, and she righted. At 11 P. M. it was almost calm; at midnight the wind came from the west, with increased violence. The wind veered with the sun, that is, from S. E. to West. Sept. 8th at 4 A. M. wind decreasing: at 6 A. M. clear weather and moderate winds. During the heaviest of the gale, the sea was smooth.*

28. *Clarissa*, Sept. 7th, lat. 36°, lon. 70°, severe hurricane from 8 P. M. till next morning, from S. S. E. to S. W.; thrown on beam-ends, with loss of topmast, sails, rudder, &c.

29. *B. L. Swan*, night of Sept. 8th, [nautical] lat. 37°, lon. 71°, hurricane, from E. S. E. going round [probably by N.] to N. W.; dismasted.

30. *Olivier*, Sept. 8th, lat. 36° 37′, lon. 69°, hurricane, from S. W. to N. E.; dismasted.

31. *Octavia*, Sept. 8th, lat. 37° 05′, lon. 68° 04′, severe gale from S. and heavy seas; damaged, and one man lost.

32. *J. W. Buddecke*, dismasted in the gale, and foundered: crew picked up on the 11th, lat. 39°, lon. 65°.

33. *Adrian and William*, Sept. 9th, lat. 39° 50′, lon. 66° 50′, hurricane; dismasted.

34. *Nauticon*, Sept. 8th, lat. 33° 15′, lon. 65°, at daylight gale commenced from S., and increased rapidly: boat's bulwarks and spars swept from the ship.

35. *Bessie Grant*, Sept. 8th, lat. 37° 30′, lon. 63°, in hurricane from N. N. E. was thrown on beam-ends and dismasted.

* Letter from Capt. Berry. Several other captains report a like effect of the most violent portion of the hurricane, in smoothing down the sea. Capt. Berry states, that from 7 to 11 P. M. the cards of his compasses were flying round from east to west like a top; perhaps at the rate of thirty times a minute. When the gale was from the western quarter the compasses were steady.

36. *Revenue*, Sept. 8th, lat. 38° 30′, lon. 64° 48′, at 10 A. M. the hurricane blew all sails from the yards; at 12 30 still increasing; hove on beam-ends at 1·30 P. M., and dismasted; at 5 P. M. hurricane abated.

37. *Liverpool*, near lat. 41° 02′, lon. 68° 23′, Sept. 9th; gale commenced from eastward, blowing hard at N. E. and N. N. E. about four hours, late in the afternoon, and veering westward; barometer at noon 29·20 in. [Estimated as 210 miles to the left of the center path].

38. *Abner Taylor*, Sept. 8th, lat. 39° 30′, lon. 66° 20, hurricane, from S. E. to N. W.; dismasted.——*Georgiana*, dismasted on the 8th, in lat 40°, and abandoned.——*Cairo*, thrown on beam-ends, on southern edge of gulf stream, and abandoned.

39. *Glamorgan*, Sept. 9th, lat. 40°, lon. 65°, hurricane, from E. N. E.; dismasted.

40. *Saragossa*, dismasted in violent hurricane, Sept. 8th, lat. 39°, lon. 63°.

41. *Queen of Sheba*, Sept. 7th, a hurricane, in lat. 39° 50′, lon. 64° 35′, in which lost spars, sails and bulwarks; with other damage.

42. *Juanito*, Sept. 8th, severe gale from N. E., lat. 40°, lon. 64°; thrown on beam-ends and dismasted.——*Tarquin*, Sept. 8th, thrown down in the hurricane, in lat 40°; lost sails, topmast, &c.

43. *Conqueror*, Sept. 8th, lat. 38°, lon. 59°, hurricane; dismasted and filled.——*Haabet*, dismasted Sept. 8th, westward of the Grand Bank; abandoned.

44. *Matchless*, Sept. 8th, lat. 39° 29′, lon. 59° 45′, severe hurricane from south four hours, when it died away and suddenly shifted to the west, blowing very violent; dismasted.

45. *Ionian*, night of Sept. 8th, lat. 40°, lon. 60°, took the hurricane from S.; which shifted to N.; was hove on beam-ends and dismasted.

46. *Henry Harbeck*, Sept. 8th, hurricane commenced at noon from the southward, lat. 40°, lon. 56°. While lying to was struck by a sea, on larboard side, with loss of bulwarks and deck house; five men lost or disabled. At 3 A. M. blowing harder, lost topmasts and sails. Ship foundered.

47. *Tuscarora*, on beam-ends, with loss of sails, &c., in a violent hurricane, Sept. 9th, lat. 41°, lon. 57°, W.

48. *Cadet*, damaged in heavy gale from N. W. Sept. 10th, lat. 43° 30′, lon. 61° 20′ W.

49. *Independent*, Sept. 9th, lat. 40° 20′, lon. 50° 30′, hurricane from S. W. to N. W.; lost topmasts, sails, &c.: at 11 A. M. the hurricane blew with its utmost fury; and the barometer had then fallen to 27·75 inches.*

50. *Wildfire*, Sept. 9th, lat. 42° 04′, lon. 51° 21′, at 11 A. M. under close reefed topsails, wind E., was struck by the hurricane and hove on beam-ends: lost mainmast, topmasts, &c., and one man.

51. *Albert Gallatin*, Sept. 8th, lat. 39°, lon. 48°, severe hurricane six hours, from S. S. E. to N. W.

52. *Charles Humbertson*, Sept. 9th, lat. 43° 16, lon. 45°, in the gale under double reefed topsails, wind suddenly changed from S. to N. without any warning and blew a hurricane; lost sails, &c.

* From the official report and protest of Capt. Smith.

53. *London*, Sept. 9th, squally, with rain; 9 A. M. barometer 29·80: noon, lat. 43° 13′, lon. 44° 12′; at 2 P. M. barometer 29·60; blowing harder; 3 P. M. bar. 29·40, with appearances of a heavy blow; wind S. veering to S. W.; 4 P. M. bar. 29·20; nearly calm, but looked threatening: At 4·30 P. M. bar. 29 inches, when the blast struck us from N. W., like a discharge of cannon; went before it furiously; burst the spencer and sprung main-yard; ship settling away every few seconds as if going down. At 5 P. M. bar. had risen to 29·20; at 6 P. M. the fury of the hurricane was broken, but the gale blew from N. W. through the night; moderating at noon of 10th in lat. 42° 27′, lon. 46°; so that at 2 P. M. we had set fore and main topsails.* [Estimated 165 miles to the right of center path.]

54. *Connecticut*, Sept. 9th, lat. 44° 30′, lon. 47°, terrific hurricane; at 10 A. M. broached to; lost spars and sails, with four seamen; at noon, gale gradually abated; ship lying to on port tack, with head N. E.

55. *Washington*, Sept. 10th and 11th, lat. 46°, lon. 48°, heavy gale at S. S. W., veering round to the northward.——*Wilton*, from Jamaica, was dismasted in the gale Sept. 10th.

56. *Nathaniel Thomson*, Sept. 10th, lat. 42° 26′, lon. 38°, severe hurricane from S. S. W. to N. N. W. for 12 hours; ship on beam ends for three hours; lost all sails.——*Juno*, for Bremen, had the hurricane Sept. 9th, lost three men: was spoken 13th, lat. 41°, lon. 42°.——*Kezia*, from Mirimichi, encountered it on the 10th, from S. E., with much damage.

57. *Mercury*, Sept. 12th [?], lat. 44°, lon. 41°, took the hurricane from S.

58. *Hibernia*, Sept. 10th, lat. 45°, lon. 42°, hurricane, from N. E. to S. W.

59. *Ossippee*, Sept. 10th, lat. 46° 30′, lon. 42° 30′, very heavy gale from S. E. to N.; split sails, stove bulwarks, &c.

60. *Western Empire*, Sept. 9th, lat. 46°, lon. 36°, hurricane, from S. E. and S. to N. N. E.; lost spars and sails, with other damage.

61. *Sardus*, Sept. 9th [10th ?], lat. 43° 16′, lon. 32° 24′, in a hurricane, lost sails and bulwarks; with other damage.

62. *Burlington*, Sept. 10th, lat. 40° 45′, lon. 29°, severe gale, 16 hours.

63. *John Winthrop*, Sept. 9th, lat. 35° 48′, lon. 29° 30′, severe hurricane, from S. W. to N.; lost spars, sails, &c.

64. *Olympus*, Sept. 10th, lat. 36°, lon. 27°, hurricane, with loss of topmasts, sails, and rigging.

65. *John Dunlap*, Sept. 11th, lat. 46° 15′, lon. 32° 15′, hurricane; lost sails, &c.

66. *Eli Whitney*, Sept. 11th, heavy gale, with damage. Sept. 12th, lat. 47° 19′, lon. 30° 38′, saw *Barbara Ann*, disabled.

67. *Clara Wheeler*, Sept. 10th, lat. 49°, lon. 35°, was thrown on beam-ends, with loss. 11th, gale still continuing, saw a large ship in dismasted condition.

* From Prof. C. U. Shepard, then passenger on the London.

68. *Robert Kelly*, Sept. 10th, lat. 46° 30′, lon. 31°, hurricane; lost sails, &c.: barometer fell to 28·15 inches.

69. *Rialto*, in the gale, lat. 50° 28′, lon. 35° 43′, shipped a heavy sea, filled cabin, shifted cargo, &c.

70. Brig *Elizabeth*, Sept. 9th, lat. 45°, lon. 29° 30′, heavy gale from S. E. to N. E.; hove on beam-ends while under bare poles; gale abated at 4 P. M. next day.

71. *Stephen Glover*, Sept. 10th, lat. 47° 13′, lon. 30° 16′, hurricane from N. W. and W. S. W.; thrown on beam-ends and dismasted.

72. *Emperor*, Sept. 10th, lat. 47° 30′, lon. 30° 30′, severe gale from S. S. E. to N. W. ending in a perfect hurricane; lost sails, spars, &c.

73. *Royalist*, dismasted in the gale, Sept. 10th, lat. 48°, lon. 30° 30′; abandoned.

74. *Southerner*, Sept. 9th, ended with increasing gale from E. S. E.: 10th, at 4 A. M. gale heavy from N. E.; 5 A. M. a hurricane; 7 A. M. broached to under bare poles; 2 P. M. wind hauled to N. N. W. blowing tremendously; barometer 28·27 in.; 7 P. M. heavy cross sea; 10 P. M. 7 feet water in hold: at 11·30 P. M. crew took to the boat. Sept. 11th, at 6·30 A. M. ship went down head foremost, in lat. 47° 15′, lon. 30° 24′.

75. *Caroline*, Sept. 10th, lat. 48° 12′, lon. 30°, gale commenced in heavy squalls from E. S. E., soon hauling to different points of the compass, and blowing a hurricane; laid six hours under bare poles; the furled canvass blown from yards, with other damage.

76. *Harvest Queen*, severe hurricane Sept. 10th, lat. 47° 10′, lon. 29° 30′; from S. S. W to N. W.

77. *George Hulburt*, for Havre, violent gale Sept. 10th, between lat. 48° and 49°; lon. 30°; was hove down and lay many hours on port-side.

78. *Palermo*, Sept. 10th, lat. 49°, lon. 31°, in hurricane from S. E., decks swept, with loss of the mate: gale continued next day from N.W.; in lat. 48°, lon. 30°. On three following days strong winds from S. W. to N. W., to lon. 18°.

79. *William Hitchcock*, lost sails, &c. in the hurricane from W. S. W. Sept. 10th, lat. 46° 30′, lon. 27°.

80. *Devon*, in violent gale, under bare poles, Sept. 12th [?], lost spars, bulwarks, binnacle, &c. &c.; lat. 46° 33′, lon. 26° 40.

81. *Victoria*, dismasted and water-logged in terrific gale from westward, Sept. 10th, lat. 47° 17′, lon. 27° 09′.

82. *Chesapeak*, Sept. 10th, lat. 47° 10′, lon. 27° 30′, severe hurricane from S. E. to N.; received much damage.

83. *Metropolis*, Sept. 10th, lat. 47°, lon. 26°, gale from S. W. to N. W.; dismasted.

84. *Josephine*, hurricane, Sept. 10th, lat. 47° 01′, lon. 24°.——Next day, passed *Lady Seymour*, dismasted.

85. *Larpool*, Sept. 11th, lat. 48°, lon. 25°, heavy gale; on beam-ends four hours, with much damage; barometer, 28·52 inches.

86. *Solway*, abandoned Sept. 11th, lat. 48° 30′, lon. 24° 30′, at 9 A. M: wind then heavy from N. Was wrecked the day previous in the gale.

87. *Alexina*, hurricane, Sept. 11th, lat. 46°, lon. 22° 50′; hove on beam-ends, with much damage.

88. *Brown*, Sept. 10th, lat. 49° 45′, lon. 25°, lying to with strong gale from S. E.; about 4 P. M. it fell dead calm for about half an hour, while rain fell in torrents; at 4·30 a sudden gust came up from the west, and continued to blow a perfect hurricane; ship hove to under bare poles, and leaking badly: 8 P. M. hurricane as violent as ever. At 1 A. M. vessel fell over and was dismasted; crew taken off on 16th.

89. Barque *Elizabeth*, at Quebec, reports; Sept. 11, lat. 47° 56′, lon. 22° 07′, experienced a hurricane from S. W. which proved to be a revolving storm. At midnight, wind veered from W. to W. N. W. At 2 A. M. being most violent, it blew away the close reefed topsails. The ship being laid to with head to the southward, escaped the vortex.*

90. *Avalanche*, Sept. 10th, lat. 48°, lon. 20° 15′; at 4 P. M. [civil time] gale very severe at S. S. E.; brought the ship under a single topsail; [bound west] at 5 P. M. barometer 28·50, was struck with a heavy gust from N. W., and thence twice round the compass: 6 P. M. lying to under bare poles, barometer 28·70; gale, after the crisis, mostly N. N. W. by compass. [N. W. nearly.] Sept. 11th, at 8 A. M. wind N. W., and so far moderated as to allow a close reefed main-topsail.†

91. *Rufus K. Page*, in the gale, Sept. 11th, lat. 39°, lon. 17°, was struck by a heavy squall from the northward and dismasted.

92. *Barque Swan*, from Lisbon, Sept. 12th [?], lat. 36° 50′, lon. 15° 25′, severe gale from E. N. E. round by S. to N. W.

93. *William Ray*, Sept. 11th, lat. 49° 10′, lon. 20° 30′, hard gales; at 4 P. M. furled all sails and hove to, in a mountainous sea; midnight, dreadful sea, ship lay on her broadside; 6 A. M. got before the wind under double reefed fore-topsail; water-logged; abandoned on 14th. The gale veered from S. by the W., to W. N. W.

94. *Euterpe*, Sept. 9th, lat. 48° 42′, lon. 19° 30′, severe hurricane, which came on at S. E. and abated at N. W.

95. *Esther G. Barney*, severe gale Sept. 10th, lat. 48° 04′, lon. 18° 36′; threw over part of cargo.

96. *Nicholas Biddle*, lat. 52°, lon. 19°, dismasted Sept. 14th [?], while lying to in a gale from N. N. W.

96 *a*. R. M. steamer *Andes*, severe gale, S. S. W. veering to N. N. W.; lat. 51° 30′, lon. 18° 30′; barometer 28·48.

97. *Constantine*, lost sails, top-gallant-masts, and sprung fore-topmast in the gale from W. S. W., Sept. 14th [?], lat. 52° 34′, lon. 17°·30′

98. *Devonport*, took the gale Sept. 10th, lat. 54°, lon. 22°; continued till 6 A. M. of 12th, with heavy sea.

99. *Commerce*, lost spars and sails in the gale, Sept. 10th, lat. 48° 53′, lon. 13° 40′.

100. *Mary Glover*, in gale from S. W., Sept. 11th, lat. 50°, lon. 14°, lost mainsail, with other damage.

101. *Susan & Sarah*, Sept. 11th, lat. 55° 20′, lon. 15° 30′, in severe gale from S. W. was hove on beam-ends; lost mizenmast and one man. Returned to port.

* It too often happens that ships, when running westward in a southerly gale in these latitudes, and being thus in the right side of the storm-path, are hove to unwittingly on the *port-tack*; perhaps as more convenient, or with a view to avoiding some loss in distance. Of the increased danger of this tack, *when in the right side of the storm-path*, in the northern hemisphere, every navigator should be informed.

† Statement of Capt. Leach.

102. *Anne*, from Orkney, for Limerick, lost bulwarks in the gale, with sundry other damages; was as far as lat. 55° 20′, lon. 10° 15′ W.; hove to for sixty hours, and drifted off Tory Island; never experienced such a sea.——*Neptune*, with loss of foremast, was passed Sept. 13th, lat. 50°, lon. 25° 40′.

103. *Zanoni*, from Greenock; Sept. 11th, lat. 57°, lon. 15°, heavy gale; sprung a leak, and was abandoned. This position is on the Rockall Bank.

104. *Virginia*, from Gothenburg, Sept. 12th, [naut.?] in lat. 60° 40′, lon. 11° 34′, encountered a heavy gale and was struck by a heavy sea which caused the ship to leak: in continuance of the bad weather, lost topmasts, and bore up for the nearest port. Had good weather previous to this gale.*

The master of an English brig who was off the Lands End of Cornwall in this gale, reported to Capt. Leach of the Avalanche that its strength was only sufficient to bring him to two-reefed topsails.

At Scilly, Sept. 10th, wind S. S. E. to S. W. fresh, with heavy rain; bar. 29·50: Sept. 11th, wind S. S. W., fresh, with rain; bar. 29·70, to 29·75.

At Holyhead, 70 miles west of Liverpool, Sept. 10th, wind E. to S. E., fresh: 11th, S. W., hard gale and squally.

On the western coast of England and coast of Ireland, the exterior portion of this cyclone set in from the eastern or southern quarter, and veered to the westward as the body of the storm passed on to the northward; with "a very heavy ground sea on the coast."

At Tobermory, I. of Mull, lat. 56° 37′, lon. 6° 04′ W., Sept. 11th, A. M., a heavy gale from N. E.: evening more moderate. The variation being 28¾° W., shows the wind at N. 6¼° W., true. In view of the trending of the strait and the high land along its northern opening, this may consist with an outside gale from N. N. W.

The foregoing accounts show the right border of the storm to have extended to the shores of England; but in no extraordinary force, and with a depression of less than half an inch in the barometer: while the axial area, with the more active portion of the cyclone, appears to have passed over the Rockall Bank or on a center-path still more distant from the British Islands, in its course toward the polar basin. See Track xxiv on the Chart.

In reviewing the daily progress and phenomena of the storm, it should be recollected that most of the sea accounts are given in nautical time, and thus are often one day in advance of the calendar. The direction of the winds being given by compass,

* The whole number of vessels noticed in the foregoing reports, is 125; of which 104 are seen to have reported their several positions at the time of the gale, or the same is otherwise indicated. I have a further list of 17 vessels, lost or disabled in the gale, making an aggregate of 142 vessels reported. Of these, no less than 75 were lost or dismasted; and 46 were crippled, or damaged: while of the remaining 21, no report of injuries was made.

Of this vast series of disasters, not one was occasioned by rocks, shoals, or a lee shore. The fate of a far greater number of vessels (probably of less commercial value,) which were doubtless exposed in this gale, cannot now be ascertained.

a correction of ten to thirty two degrees is required for the westerly variation, from off Georges Shoals to the Rockall Bank, and the shores of Europe.

The first report in the above series is important, viewed as the earliest notice, and as from a region long supposed to be free from hurricanes and gales; of which more hereafter.

The commencement of the gale at N. E. with the *Independence* (2) marks nearly its center-path. On carrying back the trace-line derived from this and subsequent reports, it appears that the *William Money* (1) was north of this line, in the right side of the gale, as relates to its course of progression. The Independence was also on the right of the center-path, during the middle and latter part of the gale, as is shown by the veering of the wind: both vessels being bound northward. The positions reported, are probably those of the noon immediately preceding the onset of the gale.

The *Hermann* (5) was bound southward. Hence her final position in the gale was probably more southward than that reported. The remarkable fall in her barometer showed a position near to the axis of the storm.*

The *Ocean Bird* (8) first encountered the gale at E. N. E., which places her in the right-front of the storm. Had she then hove to on the starboard tack, the wind would have veered by the east, as with (2); but steering south, and then scudding before the wind during the night, she crossed the center-path and ran partly round the axis of rotation; and had the gale been slower in its advance, she might thus have completed an entire circuit. This case of running with the wind, with another which I shall adduce, may be of interest to some who think we have not shown the wind's rotation.

The rate of advance appears to have lessened as the storm approached the line or axis of equal diurnal motion; the position of which, on this occasion, appears to have been somewhat above the 30th parallel of latitude.†

* In the New York Daily Times, I find a letter of which the following is an extract; which, with an obvious correction, probably gives the true place of the Hermann in the gale:——"St. Thomas, Sept. 19, 1853. On the 4th, the barometer fell, and the wind was fresh from the North, giving rise to some apprehension that a hurricane was at hand. But it was only the wind from the wings of one passing just to the north of our island. The Danish bark *Hermann* encountered it on Sept. 2nd, lat. 53°, and lon. 18°, [obviously *lat.* 18°, *lon.* 53°]. On the 4th, it had arrived to the northeast of us, where the French brig *Diamond*, and the American brig *Carlton*, from Boston, and the schooner *Ann Maria*, from Baltimore, struggled with its fury. Col. REID's Theory, or rather Mr. REDFIELD's Theory of the gyratory movements of these storms, can no longer be doubted. A vessel was seen by the *Diamond* on the 4th, dismasted."

† From the physical relations between the diurnal rotation of the earth's crust and that of the immediately incumbent atmosphere, which result from the inertia

The progression of the gale, as in former cases, appears to have been greatly accelerated after it passed the axis of equal diurnal motion, on its recurvated course through the temperate and higher latitudes. The following estimates are roughly made, by setting off the progression on the Chart, as shown in trace xxiv, reckoning in English miles, at seventy for a degree of the meridian.

From a point opposite the position of the William Money (1) to that opposite the Hermann (3)

	Hours.	Miles.	Av. per hour.
Say, - - - - -	84	1942	22
To position of Ocean Bird (8)	50	980	19·6
" Georgia (20)	62	814	13
" Addy Swift (27)	7	175	25
" Independent (49)	36	1102	30·6
" Avalanche (90)	30	1505	50
" Virginia (104)	15 (?)	758	50·6 (?)
	284	7276	

and unstable mobility of the latter, the great storms of the inter-tropical regions must necessarily have a westerly progression; the rate of which denotes the existing difference of the diurnal motion. It is shown also by numerous investigations of these storms, that their westwardly movement as integral portions of the lower atmosphere, is united, in most cases, with a constant movement *from the equator*. Hence the relative movement becomes northwesterly; and is continued until the storm reaches a parallel of latitude where the diurnal motion of the earth's crust and that of the lower incumbent atmosphere are equal. This line, or belt, I call the axis of *equal diurnal motion*. It often marks the exterior limits of the trade winds; and its position is found to vary at different times, and in different seas or regions: good examples of which are found in the several points of recurvation seen in the storm-tracks on the Chart. On crossing this axis, the diurnal motion of the lower atmosphere is found to exceed that of the earth's surface, and produces a relative movement from the west, which, combined with the continued movement from the equator, determines the route of the storm through the temperate latitudes.

This prevailing tendency or movement from the equator, in the inferior strata of the atmosphere, is equally developed in the temperate latitudes, at all seasons of the year. It is probably due to the general gravitation of the atmosphere, acting counter to the centrifugal effect of the earth's rotation: for the latter force, owing to the greater axial radius, is necessarily greatest in the higher atmosphere, in regions beyond the cognizance of our observations.

In those cases where the easterly and westerly currents of rotation are less active, or in other words, when the diurnal motion of the lower atmosphere is least unequal to that of the earth's surface, the alternate westerly and easterly progression of the storm becomes greatly modified, in degree, though subject to the same general law of planetary dynamics. This may be seen exemplified on the Chart, in tracks VII, XIX, XX, and Col. Reid's Bermuda hurricane, of Sept. 1839. This dynamical law governs the progress of all cyclones, however gentle in their rotary action; and necessarily applies to the general movements of the lower atmosphere.

The *lower atmosphere*, in my apprehension, includes all that portion of the atmosphere in which the direction of its currents can be discerned by means of natural phenomena; and, in the largest sense, with an upper limit not higher than is indicated by a pressure of fourteen inches of the barometer. In a more restricted sense, I would apply it to the lower winds and currents so far only as to include an elevation of four thousand, to six thousand feet above the surface. The latter will prob-

Thus we have an estimated distance of 7276 miles, traversed by the storm in about twelve days: at an average rate of progression of nearly 26 miles an hour.

The slower rate of progression at and near the axis or belt of equal diurnal motion, accords with results ascertained in my previous inquiries, and with those severally shown by REID, THOM, and PIDDINGTON, in the gales of the Southern Ocean and the Asiatic Seas.

In my approximated delineation of the axis line or center-path on the Chart, I have had reference to the path of greatest violence, where observations were had from both sides, and especially to the opposite veering of the wind, which is found in the opposite sides of an advancing cyclone. Northeastward of Cape Hatteras, we find the storm-center to have passed between the *Georgia* (20) and the *Swan* (25) on one hand, and the *Addy Swift* (27) on the other.

The incurvation of the storm-path toward the Azores is quite remarkable. This feature I first noticed in the case of the storm of Sept. 1846, as shown by observations extending to lat. 62° 30′, far beyond the limits of my former map, on which its track (XIX) was first delineated. This tracing, with that of the hurricane of August 1851, (XXII) has been copied on this Chart, and extended without further alteration. The number and extent of the reports obtained in the present case, have induced me to delineate this feature more fully than I first intended. Its probable relation to the expansion and perhaps the falling off of the southern portion of the cyclone toward the equator, may be considered hereafter.

Eastward of the Grand Bank, nearly all the reports are from the right side of the storm-path, and so far as appears, mostly at great distance from the true axis path of the gale. This may be owing to the diminished violence of the two left quadrants of the cyclone, caused by its accelerated progression, as well as to the paucity of reports from the more northern portions of the Atlantic, which are less frequented by navigators. That the cyclonic nucleus of the storm had become greatly enlarged, and that it pursued the general course I have indicated, appears from its wide-spread violence, and the intensity and wide extent of its influence on the barometer, and, especially, by the most northern reports. From these few northern reports, we see this violence

ably include the entire volume of all our great storms; except on high table lands or in mountainous localities.

But as regards the movements in the upper atmosphere, in regions higher than the limits first mentioned, almost nothing appears to have been yet learned; although inferences, urged with great confidence, have been sufficiently common. These inferences may be as variant as the hypotheses on which they are founded; and seldom appear reconcilable with visible phenomena, if these be widely and carefully considered.

extended beyond lat. 60°, in the general direction of the Feroe Islands, and the main entrance to the Arctic Sea.

In other cases we find, that after passing the latitude of Bermuda, the expansion of the storms is often so great that their southern portions advance nearly from west to east; but reach the successive meridians no sooner, and sometimes even later than the axial portion of the gale, which pursues a more northeasterly course. Thus in the present case, east of lon. 60°, and between lat. 35° 30′ and lat. 42° 30′, a belt of seven degrees, we have a series of thirteen observations, carrying us east to lon. 15° 25′, in lat. 36° 50′; almost to the southwestern extremity of Europe. See reports 43, 44, 46, 47, 49, 51, 56, (including *Juno*,) 62, 63, 64, 91, 92. If, instead of the broad range of our present inquiry, we were limited, as in the United States, to fewer parallels of the temperate latitudes, how readily might an east progression of the storm be shown, by these partial observations, and its true course remain unnoticed.

But I apprehend this southward expansion of the storm to have been due to something more than the centrifugal force of the cyclone, acting against the statical pressure of the circumjacent atmosphere. In such a wide-spread cyclone, whose diameter on the 9th of September extended from Newfoundland,* to beyond the Azores, or more than 1500 miles, how could its vast entireness be much longer maintained, against both the centrifugal and gravitating forces of the earth, acting in opposite directions, and with opposite degrees of effect, or predominance, on the sides respectively nearest the equator and the pole? May we not suppose that the southern portion of the gale was in process of separation or falling off toward the equator, and thus supplying the influx which sustains the inferior trade winds in northwestern Africa and the eastern Atlantic? And is not such a view supported, in some degree, by the gradually altered course of the nucleus of the storm, which in becoming more free from the equatorial influence, is left to pursue its course toward the polar basin under the predominating influence of direct gravitation?

In reference to these questions, it may be stated that the Steamer *City of London*, in her passage from the Mediterranean, where she had fine weather, left Gibralter Sept. 11th, and encountered strong gales from N. E. with heavy sea; arriving at Southampton on the 18th;—thus showing a brisk movement of the winds, at this period, toward Madeira and the lower latitudes.†

* Through the kindness of R. Dinwiddie, Esq., I am in possession of observations made at Harbor Grace, in Trinity Bay, N. F., lat. 47° 40′, lon. 53° 16′, which show that the left margin of the storm touched that place Sept. 9th, with a stiff wind from N. E., and cloudy.

† Taking into view the greatly diminished force of this gale at the entrance of the English Channel, and that we have no notice of its action in the Bay of Biscay, while we trace its violence *continuously* from off Cape Hatteras to the Rockall Bank and beyond lat. 60° on one hand, and to lat. 36° 50′ and lon. 15° 25′ on the other, with all the characteristics of a severe gale, I confess that some solution like the

Effect of the Storm-Wind on the Barometer.—The unfailing mechanical effect of the cyclonic wind in producing a fall of the barometer within the area of its circuit, and greatest in the axial region of the cyclone, is clearly seen in this storm. The following are the cases reported in which the barometer fell below 29 inches: to which I have annexed a rough estimate of the probable distance of the vessel from the axis of the storm at the time of nearest approach.

	Minimum of Barometer. Inches.	Supposed distance from gale's axis.
Hermann (5)	27·30	*near.*
Georgia (20)	28·20	45 miles.
Swan (25)	27·94	30 "
Independent (49)	27·75	220 "
Robert Kelly (68)	28·15	265 "
Southerner (74)	28·27	240 "
Larpool (85)	28·52	315 "
Avalanche (90)	28·50	430 "
Andes (96 *a*)	28·48	280 "

From observations of the barometer and winds taken at various points in the United States near the Atlantic coast, and from those made at the signal station in Bermuda, it appears that the storm was but little felt at the latter place, except as exhibiting the true cyclonic wind, from 6th to 8th, from S. E., veering gradually from S. E. to S. W., as the bearing and progression of the storm became changed; with a force of wind marked from 2 to 4; the barometer at 30·10, at noon of 5th, 6th and 7th and 30·07 at noon of 8th. The left side of the storm encroached to some extent upon the eastern borders of North Carolina and Virginia. At Scuppernong, N. C., lat. 35° 50′, lon. 76° 20′, the cyclonic wind blew from N. E., with a force marked 3 and 2, with rain; and the lower stratum of clouds [the true storm-scud or cyclonic stratum] flew rapidly from N. E.; *the upper clouds quite still.* At 9 P. M., the wind had veered to S. W. No observations of barometer. At Fort Monroe, Va., the reported direction of the storm-wind and cloud, are the same as at Scuppernong, with rain from S. W. at 9 P. M., with thunder and lightning.

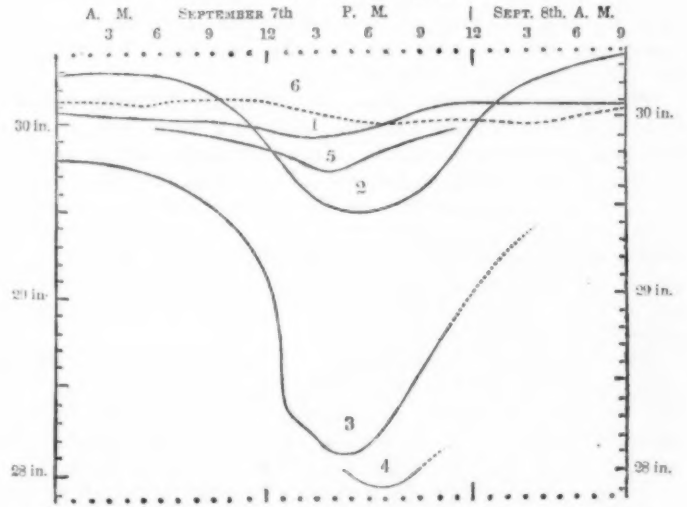
At Savannah, on the 5th and 6th, in front of the storm, the maximum of the barometer was 30·20, and 30·19; on the 7th, the minimum of the report is 30·06, and on the 8th, under the rear portion of its annular wave, 30·21. At Jacksonville, East

above is apparently required. The normal course of the circulation, or of the "current of rotation" in the basin of the North Atlantic, between latitudes 10° and 50°, as well as the routes taken by some storms which have recurvated in low latitudes, clearly indicate that a part of the out-moving atmosphere, from the inter-tropical latitudes, in the western Atlantic and the Mexican Gulf, moves in an elliptical circuit, and returns to the trade wind in the eastern Atlantic. This apparent tendency in storm-routes is seen in Col. Reid's track of the great hurricane of Barbadoes in 1780, and in my track xv, on the present Chart; also in track xiii of my former Chart, which is better seen on Chart III in vol. i of this Journal, New Series.

Florida, nearly the same: as also at Charleston, S. C., nearer to the path of the storm; and scarcely falling below 30 inches at New York and Nantucket, as the storm passed. But at Camden, S. C., 140 miles N. N. W. of Charleston and 280 miles W. S. W. of Hatteras, the successive maxima on the 6th and 8th were only 30·04, and 30 inches; showing this place to have been beyond the crest of the external barometric wave. When storm-tracks recurvate on the interior meridians of the United States, the minimum depression of the barometer frequently moves nearly parallel to the direction from Camden either to Hatteras or to Chesapeak Bay.*

The annexed diagram shows the barometric curve at Washington, Fort Monroe, steamer Georgia, and Bermuda, while the storm was passing between the latter and Washington. These two places are distant from each other about 840 miles; which perhaps may be considered as an approximate measure of the *barometric* diameter of the storm on the 7th of September. The barometric curve of the *Georgia*, if increased so as to reach the minimum of the *Swan*, may represent a section through the center of the cyclone, in the direction of the storm's progression.

Storm-Curves of barometric progression.



1. Curve at Washington: 2. at Fort Monroe: 3. Steamer Georgia: 4. Brig Swan: 5. Ship Eagle, crossing in front of storm: 6. Bermuda.

* I am indebted, on this occasion, to the officers of the Smithsonian Institution, and to Gen. Lawson, chief of the medical bureau at Washington, for observations from various parts of the United States; also to Lieut. Maury, Supt. of the Naval Observatory, for abstracts of the logbooks of Ship Eagle, and steamer Northern Light. Surgeons Williamson and Harrison of the Navy, and many ship-masters, and others, have kindly aided my inquiries.

It will be seen that the above diagram includes a period of thirty-three hours; and if we rate the progression at twenty-five miles an hour, it will comprise a distance of 825 miles. It contains the curve derived from observations on board the ship Eagle. I add the following condensed statement which is derived from the abstract of the ship's log sent me by Lieut. Maury.

The clipper ship *Eagle*, Warren, from Rio, crossed the center-path on the morning of Sept. 7th, perhaps 350 miles in front of the axis of the gale, while running in the direction of Cape May. It is interesting to find that this vessel, which crossed the equator Aug. 17th, was overtaken by the external barometric wave of the storm as early as 4th–5th of Sept., and by *a long swell coming up from S. E.;* being then from 100 miles to 60 miles southward of Bermuda. Through the 6th, winds from southeast quarter, veering to South, with *a heavy swell from S. S. W.;* latitude at noon 34° 39′, lon. 69° 32′; bar. 30·11. Sept. 7th, *a very heavy swell from S. S. W.;* wind fresh, from S. S. E. to S. S. W.; and from S. S. W. back to E. N. E.—bar. at 8 A. M. 29·90, at noon, 29·84 in. lat. 37° 17′, lon. 72° 28′: P. M. very threatening appearances from S. E. by S. to S. W., with *a very heavy swell from S. W.;* at 4 P. M. bar. 29·70,—at 5 P. M., 29·77; wind fresh from E. N. E. to N.; 8 P. M., lightning at N. W.; at 11 P. M., in a heavy squall, wind shifted to N. N. W.; no rain; heavy sea still.——Sept. 8th, cloudy; no sea; lat. at noon, 38° 38′, lon. 74° 13′; bar. 30 inches.

The steamer *Northern Light*, bound for the Isthmus, was several hours ahead of the *Georgia*, and on a more eastern track. She crossed the center-path in front of the gale, and ran through its eastern side.——Sept. 7th, lat. 34° 30′, lon. 73° 25′; through the day, strong gales from the South; with a heavy sea from S.W.——Sept. 8th, lat. 32° 01′, lon. 73°, strong gales from S.W., with heavy squalls, and *a large sea from W. N. W.:* Clear in the S. E., with stormy appearances in the N. and W.:——found the weather improving as we made south.——This account is probably in nautical time.

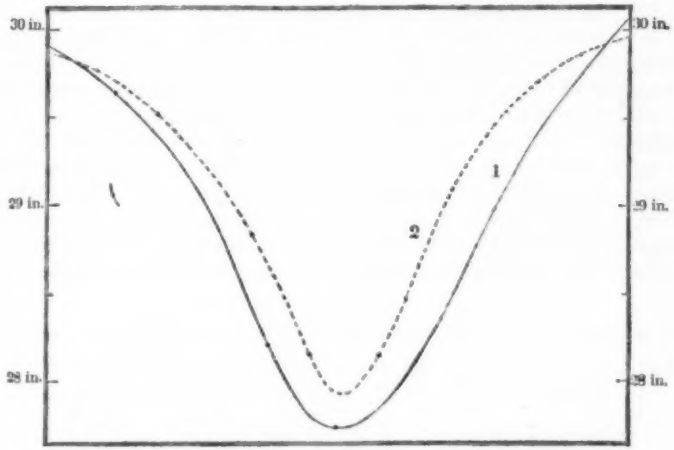
The succeeding diagram represents, in its horizontal scale, the distance of 840 miles between Washington and Bermuda. The full line (1) represents, approximately, the barometric curve through the center of the storm, *transversely to its path.* The comparison of this transverse curve with the central curve of *progression*, indicated on p. 18, is of some interest; although we have no observations intermediate to the Swan and Bermuda. The resemblance of the two central cross-curves may show that the storm was of nearly equal extent and force on all of its sides, at that time.

I have been apprehensive of a clerical error in the barometric report from Fort Monroe for 3 P. M. and 9 P. M. of Sept. 7th; and that 29·063 and 29·087, should have read 29·63 and 29·87, respectively. In preparing the second diagram I became convinced

that the correction is required; and have accordingly applied it, in tracing the transverse curve: but have drawn a short trace line to show the observations as found in the report.

I have also inserted in this diagram, in broken lines, the transverse barometric curve through the center of the Cuba hurricane of October, 1844; when in nearly the same geographical position. This curve is approximated from twenty-eight observations in the path of that storm.

Barometric Storm-Curves, transverse to the Progression.



1. Transverse centre-curve of Cape Verde and Hatteras hurricane, Sept. 7, 1853.
2. Transverse center-curve of Cuba hurricane of 1844, Oct. 6th.

Vortical Rotation of the Gale.—The true character of this gale as a cyclone, is made evident by the foregoing series of observations. This is most extensively shown by the various observations made on all sides of the storm during its passage between Bermuda and the nearer portions of the United States. The absolute whirlwind movement of the storm stratum, and the increasing rapidity of its leftwise rotation ↻ which is found in approaching the axial area, from whatever side of the storm, as well as the direct effects of this increased rotation on the fall of the barometer, in the interior portions of the gale, are made manifest by direct observation. This I might point out in full detail, were it at all necessary in the present stage of the inquiry. Nor can these results be evaded by denominating any one portion of the cyclonic wind, on either side of the cyclone, as another or distinct gale. The local variations and inequalities of the cyclonic action and the errors, imperfections or defects which may exist in the reports, are alike overborne by the amount of evidence

which serves to show the extent and general entireness of the vortical rotation in the gale.*

It would be an error to suppose that the gales and hurricanes which have been traced on our storm charts, were but exceptional cases of cyclonic action and progression in the winds of our globe. For there is a constant succession of rotary movements, greatly variant in their activity and their visible effects, and to which I shall further allude. It is the more violent cyclones, however, that afford us complete evidence of their geographic routes and their continued movement of rotation.

Of this active class, designated as hurricanes, gales, and storms, it is believed that the tracks or routes of several hundred might be added to our storm maps, by carefully collating the records which already exist. It is certain that a large number might be traced from the records and notices now in my possession or otherwise at hand; of which, the case I have now presented is but a single example. But the storms noticed in the succeeding portions of this article are selected in reference to their peculiar localities, as showing the uniform extension of the cyclonic system in equal latitudes around the globe, rather than for the amount of information possessed, regarding their extent and progression.

(To be continued.)

ART. II.—*Account of a Rainbow caused by Light reflected from Water;* by Prof. E. S. SNELL, of Amherst College.

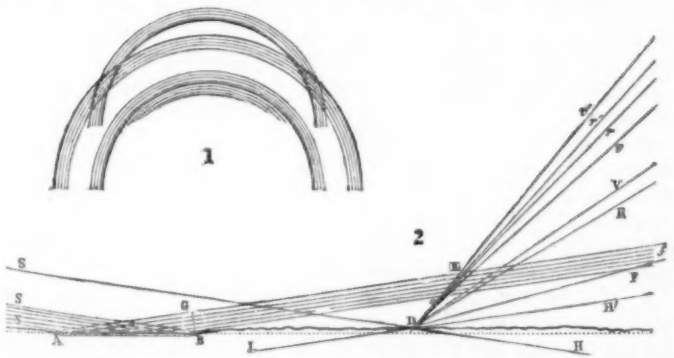
I HAVE received from my friend and former pupil, Mr. H. M. Adams, of the Theological Seminary in East Windsor, Conn., a very interesting description of a brilliant rainbow scene, witnessed by himself and others, on the 24th of Sept. last. After a slight shower, the sun shone out, about 5 P. M., and produced the usual primary and secondary bows, except that they were of uncommon brightness. Four or five supernumeraries, exceedingly vivid and beautiful, underlined the upper part of the primary, the usual attendant of a very brilliant rainbow. In addition to these, there was seen an excentric bow, quite as luminous as the secondary, but in angular size and order of colors, just like the primary, and

* While the printing of these pages was in progress I received from the government of Denmark, through Consul Bech, observations made at Oefjord, on Skage Strands Bay in the north of Iceland, in lat. 65° 40′ N., lon. 20° 40′ W.; which show the maximum pressure in advance of the cyclone to have been 29·75 in., at 1 P.M. Sept. 10th, under an east wind, the force of which is marked 2. The fall of the barometer under the cyclone continued till the night of 12th; the lowest observations being 29·12 in. at 10 P. M. of 12th, and 29·11 in. at 6 A. M. of 13th. The wind was S. E. on the 11th and 12th, and, on the rising of the barometer, was followed by the N. W. wind of the cyclone on the 13th, which afterwards changed to S. W., its force being marked 1. The normal effect of the cyclone at Oefjord, a position which is remarkably sheltered from the force of the cyclonic winds, by the peculiar outline and the extensive elevations of Iceland, is deserving of notice; not taking into account the modified direction and the abatement of force which appears to occur in the left quadrants of the gales in this highly northern portion of the Atlantic.

vertex 4° above it. Its extremities came within 15° of the horizon, and if prolonged a little, would have intersected the primary itself. This gorgeous display lasted some ten minutes, when the third bow began to fade at the top, and soon wholly disappeared. (See Fig. 1.)

Mr. Adams rightly judged that this additional bow was the effect of the sun's rays, reflected from the Connecticut river, which runs on the west side of the Seminary hill, and whose waters were then very placid. It was in fact a primary bow produced by an image of the sun in the river. As the vertex of the reflected bow was 4° above that of the secondary, or 16° above that of the primary, the image of the sun must have been 16° below the sun itself, and the sun therefore 8° above the horizon. In first considering the case, I found it difficult to conceive, that the stratum of light, reflected so obliquely from a narrow belt of water, could have sufficient thickness to form a bow occupying between 160° and 170° of a circle.

The accompanying vertical section through the axes of the bows, exhibits in their true proportions, the breadth of the river, the distance and elevation of the observer, and the thickness of the reflected sheet of light; and shows pretty accurately what



must have been the situation of the drops concerned in producing the upper and lower parts of the bow. (See fig. 2.) The breadth of the river, AB, is a little more than half a mile. The observer at D, is elevated 100 feet above the level of A B, and his distance from B, the nearest bank of the river, is three-fourths of a mile. S D H is the axis of the direct bows, inclined 8° to the horizon. The axis of the reflected bow, I D H′, intersects S D H at D, making with it an angle of 16°. A B E F is the reflected sheet of light which penetrates the shower and forms the image-bow. Its thickness in the section G B, measures about 370 feet. R D, V D, making with D H the angles 40° 17′ and 42° 2′, are the red and violet rays from the summit of the primary bow; *v* D, so much elevated, as to cross the secondary, and extend at the

r D, in like manner, mark the top of the secondary, making with D H respectively the angles 50° 59′, and 54° 9′; while r' D, v' D, are drawn so as to make the angles 40° 17′ and 42° 2′ with the axis of reflected light, I D H′. These last rays must come from drops occupying the space E e. D F is next drawn, at an inclination of 15° with the horizon, that being the estimated height of the extremities of the image-bow. This line, piercing the luminous stratum in F f, indicates the position of the drops which produced the lower portions of the bow. D E, representing the distance of the remotest drops, which could reflect the summit-rays to the eye, is about one-half of A B, or one-fourth of a mile; and these drops, if falling perpendicularly, would reach the ground within 900 feet of the observer. But the lowest rays, vertically projected in F D, must come from drops, whose least distance from the eye, is $\frac{\text{D F} \cos 7^\circ}{\cos 42^\circ\ 2'}$; since F D is 7° above the axis D H′. Now D F in the section is about equal to D B, or three-fourths of a mile. Hence the ray, whose vertical projection is D F, is $\frac{3}{4}$ m. $\times \cos 7^\circ \div \cos 42^\circ\ 2' =$ one mile in length, very nearly. The lines, B G, D E, and D F, may be readily calculated, and will be found to accord nearly with the above values. It appears, then, that the drops forming the top of the bow, cannot fall at a *greater* distance than 900 feet, while those forming the lower ends, cannot fall *nearer* than 5200 feet.

How can we account for what at first view seems to be true, that the light already somewhat enfeebled by reflection from the river, should be able to penetrate more than 4000 feet into the shower, and then return through the same 4000 feet of rain, and yet reach the eye in sufficient quantities to exhibit brilliant colors? I apprehend that this part of the phenomenon can be explained only on the supposition that several favorable circumstances conspired to produce a remarkable result.

1. The air was undoubtedly so clear that the sun shone with intense brightness. The extraordinary brilliancy of the bows, and the number and vividness of the supernumeraries, are a sufficient proof of this.

2. The shower was probably not very dense; so that the rays could penetrate into it much farther than usual, and return again to the eye.

3. A more important favoring circumstance than any other, perhaps, would be a convexity toward the observer of the nearest outline of the shower; so that, while rain was falling within 900 feet of him in a direction precisely opposite to the sun, and thus near enough to form the top of the bow, the nearest rain, on the right and left, where the extremities were seen, might be 5000 or 6000 feet distant. If the light was intense, and the drops sparse, then a much less degree of curvature might be attended with the same result. In the present instance, there can be little doubt,

I think, that the western limit of the shower was more or less convex towards the point of observation.

4. If the river bends eastward at all on the North and South of the observer's position, this circumstance would virtually add so much to its width, since the rays forming the branches of the bow would then fall lower than BF in the vertical projection. Whether this is so, I am not informed.

It is obvious from an inspection of the figure, that most of the reflected bow would disappear sooner than the direct bows, inasmuch as the angular thickness of the luminous stratum, at its intersection with the shower, would rapidly diminish as the shower retired. And, furthermore, as the vertex was produced by the nearest drops, this part must have vanished first, as was observed to be the fact.

Had the sun been about 6° above the horizon, the vertex of the image-bow would have coincided with that of the secondary; and by its opposite arrangement of colors, would have partially neutralized its tints, and made a white segment common to the two. It was in this aspect that the direct and reflected bows presented themselves to the view of Dr. Halley, in 1698, on the bank of the river Dee, of which he published an account in the Transactions of the Royal Society.

To the inquiry, why do not those, who live near a sheet of water, more frequently witness the reflected bow, it may be replied, that, if the water is not of greater width than a fraction of a mile, the favorable circumstances already enumerated will very rarely concur to produce the phenomenon with much distinctness; and if there are several miles of water, so as to reflect a beam of large vertical thickness, yet the surface would very rarely be smooth enough, directly after a shower, to form a single and well-defined image of the sun. And it may be added, that there are few persons, except such as have made the theory of the rainbow a matter of careful study, who would consider a bow as particularly noticeable and worthy of description, simply because it happened to intersect the others, especially if, as must ordinarily be the case, the intersecting bow was only a short and indistinct arch.

ART. III.—*On Changes of the Sea-Level effected by existing Physical Causes during stated periods of time;* by ALFRED TYLOR, F.G.S.*

Introduction.

THE First Part of the ensuing paper is occupied with the details of the probable amount of the solid matter annually brought into the ocean by rivers and other agents, in suspension and solution; and the conclusion is arrived at, that the quantity of detritus thus distributed on the sea-bottom would displace enough

* From the Philosophical Magazine for April, 1853.

water to cause an elevation of the ocean-level to the extent of at least 3 inches in 10,000 years.

In the Second Part an endeavor is made to compute the number of such periods of 10,000 years that must have elapsed during the accumulation of the immense mass of recent freshwater strata said to exist in the valley of the Mississippi.

The calculation as to the latter is made from the *data* collected by observers in America, of the extent of the deposit in question; and it is here supposed, first, that in former periods the *same* quantity of mud as at present has been annually carried into the Gulf of Mexico; and secondly, that the amount of sediment deposited on the delta and plains of the Mississippi does not exceed *one-tenth part* of the solid material which has been carried out (suspended in the water of the river) into distant parts of the Gulf of Mexico, or into the Atlantic Ocean itself.

From recent accounts by Mr. C. Ellet, of the United States, it appears that a column of fresh water, 1¼ mile wide and about 7 feet deep, is constantly entering the Gulf of Mexico at a speed of 2 to 2½ miles per hour, and floats on the surface of a stratum of salt water, to which it partially communicates its own velocity. And below this a stratnm of sea-water is found to be flowing in an opposite direction to that of the two strata of fresh and salt water above it. See figs. 1 and 2.

From the data submitted, it would appear that the accumulation of the alluvial deposit of the Mississippi must have occupied a great number of periods, during each of which an elevation of the sea-level of 3 inches may have occurred.

The general conclusion arrived at is, that the sea-level cannot be considered as stationary for practical geological purposes, since the operation of present physical causes would produce a considerable change in its height, even during the construction of a recent deposit like that in the valley of the Mississippi, which may be called small and local compared with those older formations familiar to geological observers.

But the subsidence and elevation of the crust of the earth would be accompanied by alterations of the area of the sea-bed; and the frequency of such movements would therefore furnish additional reasons for not considering the sea-level permanent for the lengthened periods requisite for the accumulation of sedimentary deposits of any magnitude.

In the Third Part of this paper an attempt is made to direct attention to the difficulty of finding any test by which to distinguish strata gradually accumulated during a long-continued upward movement of the sea-level, from those strata formed on a sea-bottom slowly subsiding while the ocean-level was stationary. In either case no change of depth of water may have occurred of sufficient importance to cause the removal of the Mol-

lusca inhabiting the locality, and therefore the discovery of *the same species of organic remains from top to bottom of a thick deposit* is not an absolute proof (as has been supposed*) that

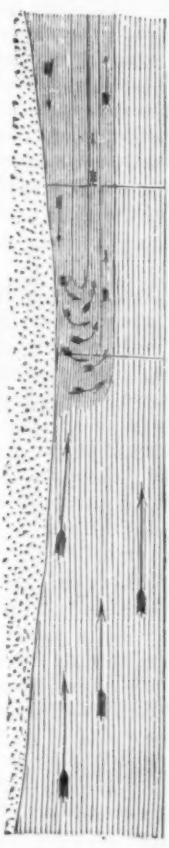
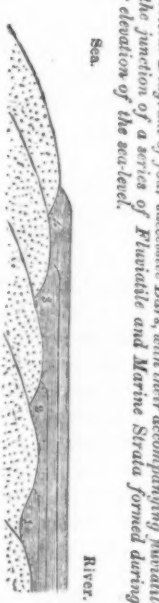


Fig. 1.—*Section of the Bar of the Mississippi.*

The Bar.

1. Stratum of fresh water, 7 feet deep, running per hour from 2 to $2\frac{4}{10}$ miles, and passing over the Bar without losing its velocity.
2. Stratum of salt water, 1 foot deep, running at the same speed as No. 1.
3. Ditto, running at 1 mile per hour.
4. Ditto, supposed to be stationary.
5. Ditto, flowing towards the Bar.

Fig. 2.—*Theoretical Diagram of four successive Bars, with their accompanying fluviatile deposits, showing a section of the junction of a series of Fluviatile and Marine Strata formed during either subsidence of the land or elevation of the sea-level.*



a, *b*, *c*, *d*, 1st, 2nd, 3d, and 4th Bars of marine formation. 1, 2, 3, 4, 1st, 2nd, 3d, and 4th fluviatile deposits.

The marine stratum *a* is contemporaneous with the fluviatile stratum 1; *b* with 2; *c* with 3; and *d* with 4. This holds good whether the land has subsided or the sea-level risen.

* "In formations from a few hundred to a thousand feet and upwards in thickness, the whole of which does actually belong to the same geological age, and is therefore characterized by the same fossils, most curious and important results may be sometimes deduced if the position or relative heights at which the groups of fossils are imbedded be noted; and this is a point usually neglected. For, thanks to the researches of Prof. E. Forbes, the depth of water under which a collection of shells lived can now be approximately told; and thus the movement of the crust of the earth, whilst the strata including the shells were accumulating, can be inferred.

"For instance, if at the bottom of a cliff, say 800 feet in height, a set of shells are buried which must have lived under water only 50 or 100 feet in depth, it is clear that the bottom of the sea must have sunk to have allowed of the deposition of the 700 feet of superincumbent submarine strata; subsequently the whole 800 feet must have been upraised." (Darwin.)

gradual subsidence has occurred during that particular formation; because the condition of equal depth of water during any deposit might be produced either by subsidence of the sea-bottom or elevation of the sea-level, or by both conjointly.

In discussing these questions, the writer has not assumed that during gradual subsidences or gradual elevations, greater denudations or depositions would occur than when the level of the land and sea-bottom was stationary; because it is not certain, either that during such gentle oscillations the forces that would produce denudation are sensibly diminished or increased, or that the rocks which are brought within the reach of denuding forces are necessarily more easily worn away than those which were previously exposed to the same influences.

Part I.

It has long been acknowledged that the quantity of detritus annually carried into the ocean from various sources must displace an equal volume of water, and thus tend to raise the level of the sea. Many years since it was estimated by an Italian that this change might amount to one foot in a thousand years. The general opinion on this subject has been, that the effects produced by the present supplies of detritus would be too minute to be perceptible, and on geological inquiries the ocean-level has been considered as permanent for all practical purposes.* I here propose to offer the evidence of present denudation in certain countries where careful observations have been made, in order to show, that, if such rapid destruction of land occurs in most localities, then the operation of present physical causes must be amply sufficient to effect a perceptible alteration in the sea-level in a moderate space of time.

The mere consideration of the number of cubic feet of detritus annually removed from any tract of land by its rivers, does not produce so striking an impression upon the mind as the statement of how much the *mean surface level* of the district in question would be reduced by such a removal. This information may be obtained by calculation from the published accounts of the quantity of mud annually abstracted from districts of known dimensions by their rivers. In this manner it is found that the Ganges would in about 1751 years, at its present annual rate, carry away from the land it drains (which is supposed to be about 400,000 square miles) as much detritus as would cover that area to the depth of one foot, as the following calculation will show:

Thus, 27,870,400 (superficial feet in a mile) $\times$ 400,000 = 11,151,360,000,000, the number of superficial feet in the area of 400,000 square miles drained by the Ganges. The number

* Manfredi. See Lyell's Principles, edit. 1850, p. 270 and 542.

of cubic feet of detritus discharged annually by that river is 6,368,677,400. (See Lyell's Principles.)

$\frac{6,368,677,400}{11,151,360,000,000} = \frac{1}{1751}$; consequently the reduction of the mean level of the Ganges district is $\frac{1}{1751}$ of a foot annually, or 1 foot in 1751 years.

6,368,677,440 cubic feet of mud discharged × 856 water to mud = 5,444,074,288,640 = the number of cubic feet of water annually discharged by the Ganges.

$\frac{5,444,074,288,640}{11,151,360,000,000}$ = about ½ a foot, so that the mean annual discharge of water is equal to about 6 inches of rain on the whole area of 400,000 square miles.

The Mississippi, on the other hand, would occupy 9000 years at its present annual rate in reducing to the amount of one foot the mean surface-level of the district it drains, which is computed at eleven hundred thousand square miles. The result is obtained as follows:

If 3,702,758,400 cubic feet of mud are annually carried down by the Mississippi (since the mud is to the water as 1 to 3000), 3,702,758,400 × 3000 = 11,108,275,200,000 = the number of cubic feet of water annually carried by the river into the Gulf of Mexico. The area of district drained by this river is stated at 1,100,000 square miles – 5280 × 5280 = 27,878,400 = the number of superficial feet in a mile—27,878,400 × 1,100,000 = 30,666,240,000,000 = the number of superficial feet contained in the area of 1,100,000 square miles drained solely by the Mississippi.

$\frac{11,108,275,200,000}{30,666,240,000,000}$ foot = ⅓ foot nearly. Consequently the water carried down by the river is equal to about 4 inches of rain over the surface of land drained.

If it be assumed that the levels of the rivers, lakes, and springs are the same in this district at the same period of two consecutive years, the water sufficient to produce the above-mentioned 4 inches of the total of rain-fall upon the whole of this district must have been annually derived from clouds which have been charged with vapor in parts of the earth beyond the confines of the tract of country under consideration; since, if the 4 inches of rain annually carried into the Gulf of Mexico were not replaced from foreign sources, the levels of the rivers, lakes, and springs must rapidly fall.

The estimate of denudation obtained from these countries may be incorrect when applied to other lands differing in altitude and receipt of rain. Besides, many rivers empty themselves into lakes and inland seas, and other extensive tracts are entirely with-

out rain. Since there must be extensive districts which contribute no detritus whatever to rivers, I propose to *assume* that one half the earth's surface only is drained by rivers flowing directly into the sea,* and that the average supply of detritus does not exceed that afforded by the district through which the Mississippi flows (a country where there are no very high mountains, and only a moderate quantity of rain).

The quantity of soluble salts annually carried into the ocean must amount to a very large volume, particularly as river-water always contains matter in solution, while it is only during two or three months of the year that alluvium in suspension is carried down in large quantities. The proportion of soluble salts in the water of the Thames is 17 to 70,000, or 1 to 4117; while the proportion of alluvium suspended in the water of the Mississippi is as 1 to 3000.†

The level of the land is as much reduced by what is carried away in solution, as if this were mud and sand removed in suspension; and a submarine deposit formed from materials brought into the sea in solution will displace a volume of water equal to their former bulk; and therefore, when the annual supply of soluble salts to the ocean does not exceed the quantity separated from solution, the same effect will be produced upon the sea-level by matter introduced, whether it be in solution or suspension. While the proportion of the land to the ocean remains as 1 to 3.‡ it is evident that a reduction of 3 feet in the mean surface-level of the land must take place by denudation before a volume of detritus would be conveyed into the sea sufficient to displace enough water to occasion an elevation of one foot on the ocean-level. (See fig. 3.)

There is great need of further information respecting the amount of sediment carried down by other rivers besides those mentioned; yet if the rate of denudation obtained from the statistics of the Ganges and Mississippi be any guide to what is occurring on the remainder of the globe, we cannot suppose that an *indefinite* time would be required for the performance of a denudation, which should reduce the mean surface-level of the land 3 feet and raise that of the ocean 1 foot. It was during the contemplation of the changes of level that might have been produced by the operations of ordinary physical agents upon the surface of the earth, that Hutton was led to remark that it was not necessary to suppose the area of the land always maintained the

* By reference to Johnston's Physical Atlas, the calculated proportion of land drained by rivers running into European lakes and inland seas may be seen.

† For the statistics of the Mississippi River, see Sir Charles Lyell's Second Visit to the United States, edit. 1847, vol. ii. p. 249 to 253, and other places.

‡ M. Balbi shows (Atlas, Soc. Diff. Useful Knowledge, 1844) that the land on the globe equals 37,647,000 square geographical miles, the sea equals 110,875,000 square geographical miles.

same extent, but that from time to time new land would be formed by the elevatory movements of the sea-bottom to compensate for what had been carried into the ocean by the continued operations of rivers and breakers.* In speaking of the elevation of the sea-level, I only refer to the intervals between those movements of the land which might neutralize in an instant all that had been effected by the operation of rivers for immense periods of time.

It would add very much to the interest of this inquiry if any proof could be brought forward of a recent gradual upward movement of the sea-level. This would, however, be difficult to observe,† on account of the rise in the water concealing the evidence of its former level, except just at the mouths of rivers, where the deposits of fluviatile alluvium might raise the land from time to time and keep it always above the rising waters.

The deposits situated at a few such localities have been described by the best observers, and I hope to show that in several cases there are appearances which might be partly explained by changes of the sea-level, but that a much greater number of cases and more certain evidence would be needed before such an event could be satisfactorily proved. I propose to make some remarks upon this point, after having submitted the evidence which has induced me to believe that the supply of detritus under present

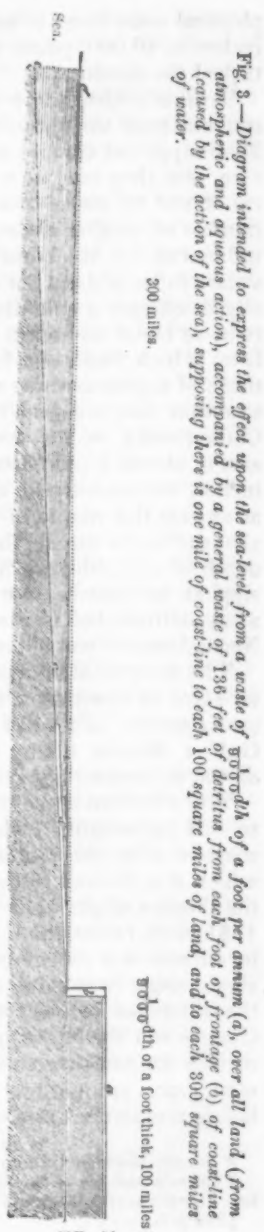

Sea.
300 miles.
$\frac{1}{1000}$th of a foot thick, 100 miles long.
Land.
Sea-level.
The horizontal dotted line (*c*) indicates the rise of sea-level equal to $\frac{1}{10,000}$th of a foot per ann.

Fig. 3.—*Diagram intended to express the effect upon the sea-level from a waste of* $\frac{1}{1000}$*th of a foot per annum (a), over all land (from atmospheric and aqueous action), accompanied by a general waste of 136 feet of detritus from each foot of frontage (b) of coast-line (caused by the action of the sea), supposing there is one mile of coast-line to each 100 square miles of land, and to each 300 square miles of water.*

* "It is not necessary that the present land should be worn away and wasted exactly in proportion as new land shall appear; or conversely, that an equal proportion of new land should be produced as the old is made to disappear." (Hutton's Theory of the Earth, 1795, vol. i, p. 196.)

† See Darwin, Coral Reefs, &c., edit. 1851, p. 95.

physical conditions is sufficient to raise the ocean level 3 or 4 inches in 10,000 years, provided no subsidence or elevation disturbed the result.

To this subject I now proceed. Sir Charles Lyell's published statements of the quantity of mud annually carried down by the Mississippi and Ganges appear to have been made with so much care, that they may be a better guide to the general rate of removal of soil by rivers than information obtained from a greater number of smaller rivers, which of course are more likely to be influenced by local circumstances. Eleven hundred thousand square miles of land are drained by the Mississippi,* which annually discharges a quantity of water equal in volume to 4 inches of rain, or about one-tenth of the total rain-fall over this entire surface, which forms one-fifth part of North America.† From the mean of a great number of observations, the average quantity of alluvium suspended in the water appears to be 1 part in 3000. Consequently, as the water annually drawn off would cover an area of eleven hundred thousand square miles to the depth of four inches, the quantity of mud removed in the water (as measured at or near the mouth of the river) would cover the same extensive surface to the depth of $\frac{1}{3000}$dth part of four inches, or to the depth of $\frac{1}{9000}$dth part of a foot. Or, in other words, the Mississippi at its present rate would occupy 9000 years in carrying away detritus before the mean surface level of one-fifth part of North America would be reduced one foot.

The Ganges discharges into the Indian Ocean a supply of water equal to about six inches of rain on 400,000 square miles, or a much greater volume of water than the Mississippi pours into the Gulf of Mexico, taking into consideration the difference in size of the countries they drain.

The alluvium suspended in the waters of the Ganges‡ is as 1 to 858 by weight; consequently the detrital matter removed in suspension by the water in one year would cover the land from which it is derived to the depth of $\frac{1}{1751}$ of a foot; that is to say, the Ganges might pour out muddy water at its present rate for 1751 years before the mean level of 400,000 square miles would be reduced one foot in height. The great elevation of the Himalaya range, or possibly a greater rain-fall, may probably occasion the difference between the rates of denudation indicated by the Ganges and the Mississippi. As there are also parts of the earth's surface drained by rivers flowing into lakes and inland seas, and other tracts are entirely without rain, I propose to estimate (as before mentioned) that only half the land contributes detritus in

* See art. Mississippi, Penny Cyclopædia, vol. xxv, p. 277.

† The total rain-fall of the United States is 39 inches between 24½° and 45° N. lat. (Berghaus and Johnston.)

‡ See p. 6.

suspension to rivers flowing directly into the sea.* If this area be annually reduced in level at the same rate as the district through which the Mississippi flows, then the mean level of the land on the globe would be reduced 3 feet in 54,000 years, and consequently the level of the ocean raised 1 foot in the same period by means of the detritus suspended in river-water poured into the ocean.†

But in addition to the sediment carried down by means of rivers, we have also to take into consideration the amount of debris washed into the sea from cliffs during so long a period as that mentioned. It is difficult, however, to form any estimate of what this would annually amount to, for old maps and charts are hardly accurate enough to represent the waste of cliffs by breaker-action even within the last 100 years. Capt. Washington has, however, published a report‡ which gives an account of the encroachment of the sea at intervals on one part of the Suffolk coast. This will give a general idea of the contribution of detritus that may be obtained from some points of a coast-line. The following statements are collected from Capt. Washington's Report on Harwich Harbor in 1844, from which also the figures 4, 5, 6, 7, are copied.

The cliff on the western side of the harbor is about 1 mile long and 40 feet high, and the encroachment of the sea appears to have been at the rate of 1 foot per annum between the years 1709 and 1756, so that the annual supply of detritus was equal to 40 cubic feet for each foot of frontage. Between 1756 and 1804 the advance increased to nearly 2 feet per annum; so that the annual removal of cliff amounted to nearly 80 cubic feet for each foot of frontage.

Between 1804 and 1844 the encroachment of the sea averaged 10 feet per annum, and the annual removal of detritus must have amounted to 400 cubic feet for each foot of frontage. It was during this latter period that extensive dredging for cement stone took place at the base of the cliff.

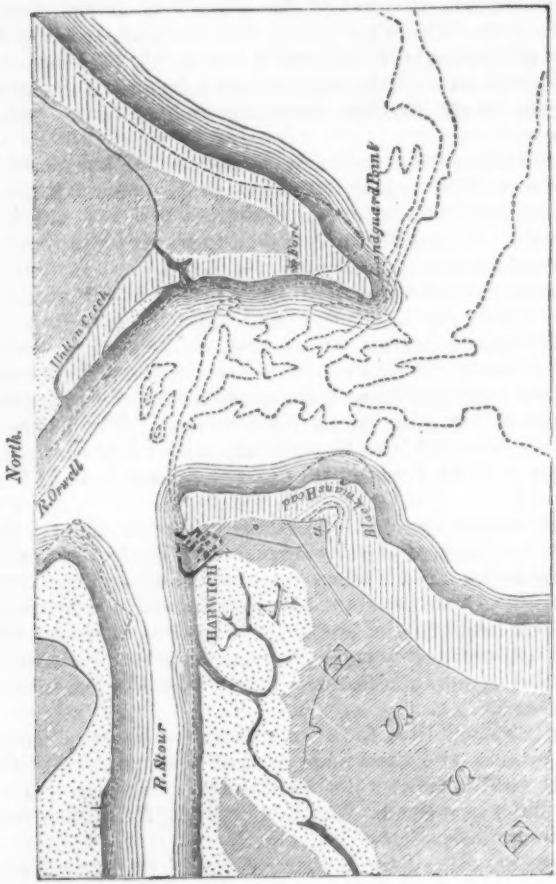
On the eastern side of the harbor events of an opposite character have occurred, for Landguard Point has gained 50 feet per annum in length during the last 30 years. The addition thus made to the land, and to the "littoral zone," presents an interesting example of the rapid accumulation of a local deposit under favorable circumstances. From the appearance of the beach, it would appear that the shingle and sand of which it is formed

* The proportion of land without rain is about $\frac{1}{1200}$dth of the whole. Keith and Johnston say that nearly one-half the drainage-water of Europe and Asia falls into the Black and Caspian Seas. The proportion for Africa and America is not known.

† It is not improbable that the *solvent* powers of rain and river-water are as important agents in the removal of land as the agency above mentioned. Definite calculations on this subject remain to be made.

‡ Tidal Harbors' Commission, First Report of 1845.

Fig. 4.—*Map of Harwich.*

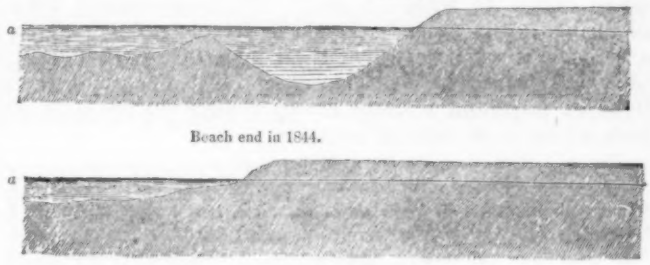


a. Beacon Cliff, with dotted lines indicating the changes that have taken place in high and low-water mark. The dotted line shows the former outline of Languard Point.

Fig. 5—*Section showing the Destruction of Beacon Cliff between* 1752, 1804, *and* 1844.

have been brought from the north, in which direction there are recorded instances of great destruction of land by storms during the last 300 years. The aspect, however, of much of the coast-line appears as if it had remained unaltered for a very long period, except in the manner Mr. R. A. C. Austen* alludes to when he remarks, "that although the sea for months together, and in places even for whole years, may not acquire any fresh spoil, yet there are few hours when its waters are unemployed in fashioning and abraiding the materials already acquired." In considering the effect upon the sea-level caused by sand, mud, and pebbles washed in by the breakers, it is only necessary to regard those materials that may be brought in from cliffs above high-water mark; for the movement of sand and mud below high-water mark can produce no effect upon the sea-level, because the abstraction of these materials from one part of the shore is exactly balanced by their addition to some other part. For instance, some of the flint-pebbles which have contributed to the recent deposit at Landguard Point have been brought along shore a great distance from their original position on the cliff. These flints formed an addition to the sea-bed, and tended to raise its general level by displacing an amount of water equal to their bulk the moment they fell on the shore below high-water mark; and it is quite clear their subsequent movements, either beneath the wave or on the beach, could produce no further effect upon the sea-level, the spaces they occupied on one part of the coast being balanced by the vacancy left at some other. It is also evident that the beach at Languard Point will go on extending so long as the fresh supplies of shingle and sand from the north exceed the removals southward.

Figs. 6, 7.—*Sections showing the Increase of Landguard Point between* 1804 *and* 1844



a. a. Low-water level of ordinary springs.

In the same manner the continued supplies of pebbles from the westward enables the Chesil Bank to preserve its position. As

* Austen, Quart. Jour. Geol. Soc. vol. vi. p. 71–73; and De la Beche, Geol. Observer, 1851, p. 65.

soon, however, as any disturbing causes interrupt the supplies of new material, the sand and shingle beaches dependent upon them must soon disappear; and in fact the termination of every beach will be at that point where the waste and abrasion by breaker-action are balanced by the supply of pebbles and sand drifted from other places. Although it appears clear that only the detritus obtained from cliffs above high-water mark need be taken into calculation, yet I regret to find that scarcely any data of this kind exist, and therefore it is not possible to ascertain the probable effect upon the sea-level that is being produced by the detritus so derived. In the same manner the per-centage of soluble salts in the water of the few large rivers of which notes have been published has not been given separately from the per-centage of matter in suspension, and therefore we are in ignorance of the supplies that are annually introduced into the ocean from the formation of submarine deposits from materials dissolved in the sea-water. When the rise in the sea-level from the effect of alluvium brought in suspension by rivers was being considered, I supposed that that cause alone might produce an elevation of one foot in 54,000 years; but in order to make some allowance for the similar effects that must be produced by the introduction into the ocean of materials from above high-water mark on coast-lines* by breaker-action, and also by the formation of submarine deposits from materials which were brought into the ocean in solution, I now propose to consider that all these causes together might produce an elevation of the sea-level equal to one foot in 40,000 years, or three inches in 10,000 years.

Mr. Darwin has remarked, that "the knowledge of any result, which, with sufficient time allowed, can be produced by causes, though appearing infinitely improbable, is valuable to the geologist, for he by his creed deals with centuries and thousands of years as others do with minutes." For these reasons, even if, upon further investigation, it should be found that the true rise in the sea-level is much less than three inches in 10,000 years (in periods undisturbed by subsidences and elevation), yet it may still be an important element in accounting for those changes which we are now about to consider.

(To be continued.)

* The rough estimation of the extent of coast-line, kindly supplied by Mr. A. K. Johnston, (Nov. 1852), is as follows:—

	Nautical miles (60 to a degree.)	English statute miles (69½ to a degree.)
Europe, - - -	17,200	20,425
Asia, - - - -	30,800	34,825
Africa, - - -	14,000	16,625
America, - - -	37,600	44,656
	99,600	116,531

ART. IV.—*On the Phosphate of Iron and Manganese from Norwich, Mass;* by Dr. J. W. MALLET.

THIS mineral, first observed by Dr. E. Hitchcock, Jr., and Mr. Hartwell, and since described by Professor Dana and analyzed by Mr. Craw,* possesses much interest from the distinctness of its crystals (which yet in their angles present unaccountable irregularity), since it belongs to a class of minerals which are in general found massive, or but imperfectly crystallized. The following are the results of a chemical examination of some pure specimens, for which I am indebted to Mr. C. Hitchcock. They do not add much to our knowledge of the mineral, but serve to confirm essentially the former determinations by Mr. Craw.

The crystals are opaque and of a dark brownish black color, and give a beautiful violet streak. Sp. gr. = 3·364, higher therefore than that of the specimen analyzed by Mr. Craw, which he gives as 2·876. Hardness about 5. Before the blowpipe the reactions of phosphoric acid, iron, and manganese, are easily obtained.

A portion of the mineral was pulverized, weighed, and kept for some time at the temperature 100° C. The loss of weight was scarcely appreciable. This portion was then exposed to a bright red heat, and on cooling was found to have assumed a light brownish yellow color, and to have lost 6·33 p. c. In another experiment the loss was 5·97 p. c. To ascertain the amount of water contained in the mineral, a portion, dried as before at 100° C., was heated in a glass tube in a stream of dried air, and the water expelled was absorbed by chlorid of calcium and weighed. It amounted to 1·92 p. c. In another experiment the pulverized mineral was heated in dry hydrogen, and lost 2·18 p. c. of water beyond that formed by the reduction of the peroxyds of iron and manganese to protoxyds.

The phosphoric acid and peroxyds were determined by fusion with carbonate of soda, and the lime, magnesia, and lithia, were estimated in a separate portion. The results of analysis were—

	1.	2.	3.	4.
Phosphoric acid, - -	43·12	43·35	42·65	——
Peroxyd of iron, - -	29·90	29·23	29·37	——
Sesquioxyd of manganese,	23·02	21·98	22·76	——
Lime, - - -	——	——	——	·09
Magnesia, - - -	——	——	——	·73
Lithia, - - -	——	——	——	1·79

* Amer. Jour. of Science, [2] xi, 99, 100.

The iron and manganese appeared to exist altogether as sesquioxyds. The lithia contained a little soda, but the quantity of the latter was too small to separate and weigh.

The mean of these results makes the composition of the mineral—

		Atoms.	
Phosphoric acid,	43·04	·598	
Peroxyd of iron,	29·50	·369	·654
Sesquioxyd of manganese,	22·59	·285	
Lime	·09	·003	·163
Magnesia,	·73	·036	
Lithia,	1·79	·124	
Water,	2·05	·228	
	99·79		

Hence we have the complex and not very probable formula $5\dot{R}^4\ddot{P}^3+\dot{R}^5\ddot{P}^3+7\dot{H}$; but if we consider, as suggested by Mr. Craw, that the iron and manganese originally existed as protoxyds, the above numbers give the equivalents of phosphoric acid, protoxyds, (adding in the lithia and earths), and water, in the ratio 598 : 1471 : 228, or very nearly 2 : 5 : 1, although the water does not amount to quite 1 atom. Hence we have the much simpler formula, $\dot{R}^5\ddot{P}^2+\dot{H}$, which is that of Damour's alluaudite, if we reduce the per- to protoxyds as above, though that mineral differs from the present in containing soda instead of lithia, and in the manganese actually existing to a great extent as protoxyd, while in the substance from Norwich the peroxydation of the metals has been completed.

There have been already described three phosphates occurring in nature which have this general formula, with the exception of the water, which varies in amount in each—1st, this mineral from Norwich and the Alluaudite from Limoges, the formula of which is $\dot{R}^5\ddot{P}^2+\dot{H}$; 2nd, Heterosite or Hetepozite, of Dufrénoy, from Limoges, with the formula $\dot{R}^5\ddot{P}^2+2\dot{H}$; and 3rd, Hureaulite, also from Limoges, and represented by $\dot{R}^5\ddot{P}^2+8\dot{H}$. Whether any of these minerals deserve to rank as distinct species seems very doubtful. It would seem more likely that they are all the mere products of a gradual alteration, in the course of which the heavy metals were more or less peroxydized, water was taken up, and probably some of the alkaline constituents of the mineral were lost.

This last mentioned action seems indicated as having affected the lithia of the phosphate from Norwich, since the phosphoric acid found is a little in excess of that required by the formula.

Art. V.—*On the Homœomorphism of Mineral Species of the Trimetric System;* by James D. Dana.*

Although many cases of homœomorphism among minerals of the Trimetric System have been pointed out by different investigators, no general review of the species has yet been made. We propose, therefore, to consider the relations in form among all the species, believing that in this way, and in this way alone, we may arrive at the true system among the homologies, and the principles upon which they rest.

In the outset, it is important to ascertain what may be considered true criterions of homology in the comparison of forms. In a trimetric crystal there are often several occurring prisms in the three axial directions, the vertical, macrodiagonal, and brachydiagonal, and as either axis might be assumed to be the vertical axis, and either prism in each direction the fundamental prism,† there are wide limits as to the possible cases of homœomorphism that might be made out. So among rhombohedral forms, in Calcite for example, rhombohedrons occur of a great variety of angles, and homœomorphism may be deduced between it and almost any rhombohedral species, provided any one of these rhombohedrons may for the time be taken as fundamental.

There is obviously one right position for the comparison of two species, and the others are wrong. Hence it is essential to have some basis for deciding upon this point, and especially for ascertaining which is the true vertical axis, in order that we may compare like axes and their planes with one another.

It must be admitted that there are no tests of homology which are of invariable application. As elsewhere in science, the relations of species are to be ascertained rather by the general range of characters, than by the severe application of one single law. But there are important aids, and their exact value should be understood.

1. *Cleavage.*—Cleavage is one of the most important means. In the trimetric system, it may take place parallel, (1) to the axial sections, one or all; (2) to the lateral planes of different rhombic prisms; (3) to octahedral planes.

a. When cleavage is parallel to one or more rhombic prisms, it is generally true that, (1) the vertical axis of the prism of most perfect cleavage is the proper vertical axis of the species, and also that (2) these cleavage prisms for different species are homologous prisms.

* From the Annals of the Lyceum of Nat. Hist. New York, vi, 37, March, 1854.

† A fundamental vertical prism is one which has for its axes b, c, the ratio $1b : 1c$. The fundamental macrodome and brachydome have the analogous ratios $1a : 1b$, and $1a : 1c$. These are the *unit* prisms.

Hornblende and Augite correspond to the *first* of the two principles just stated, but are well known exceptions to the *second:* the cleavage prism of one has twice the breadth of that of the other. These species, nevertheless, are closely homœomorphous, and hence there may still be homology when the cleavage forms have a simple axial relation, as 1 : 2. Diaspore and Göthite exemplify the same fact; the former has an imperfect cleavage parallel to the prism $i2(\infty \bar{P}2)$. Staurotide and Andalusite may be viewed as another example. The occurring forms of these species have the same relation as those of hornblende and augite, or a ratio of 1 : 2, in the longer lateral axis, and traces of cleavage correspond; while in topaz, a third homœomorphous species, both forms are common, and indistinct cleavages are described as occurring parallel to each.

In some cases, when there are two cleavage prisms at right angles with one another, we are required by the analogies of the species to take as the vertical axis that parallel to the prism of least perfect cleavage; but such examples are rare.

b. It is common to find a prismatic and a diagonal cleavage existing together. In a single natural group of species, the former may become obsolete, while the latter is highly developed, or the reverse; and therefore *the presence or absence of a diagonal or basal cleavage is no test of identity.* The anhydrous sulphates are a prominent example. In *Celestine* and *Heavy Spar* a basal and prismatic cleavage exist, and the two diagonal cleavages are imperfect; while in *Anhydrite*, of the same group, the basal and diagonal are highly perfect, and no prismatic cleavage has been detected. In rhombohedral forms, a basal cleavage often occurs along with a rhombohedral, and in species actually homœomorphous, it may become the only cleavage, or be wholly obsolete. It is, however, often true, that a particular direction of cleavage characterizes a group of species. In the *Heulandite* group there is a perfect clinodiagonal cleavage; the *Feldspars* have a basal and clinodiagonal; the species of the *Calcite* series have a perfect rhombohedral cleavage, and no distinct basal, while the *Corundum* series have generally a basal cleavage, more distinct than the rhombohedral.

2. *Twin-composition.*—In compound crystals composition takes place in general, parallel to planes or sections of fundamental value. This is well seen in monometric forms, in which the only planes of composition are, (1) the faces of the cube; (2) the faces of the regular octahedron, or planes truncating the solid angles; (3) the faces of the dodecahedron, or planes truncating the edges of a cube. It will be observed that the composition is either at the extremities of the axes (1), or at points exactly intermediate between *three* axes (2), or between every *two* (3). This narrow limit to the possible directions of

twin-composition gives importance to its indications, and therefore *similarity in modes of composition suggests identical or homologous relations between the planes of composition in different species, and vice versa.* Thus when we observe different species, as *Aragonite*, *Cerusite*, etc., affording stellate twins and hexagonal forms by composition parallel to the faces of a prism nearly 120° in angle, we infer that the prisms are homologous; and when similar prisms occur in *Chrysoberyl* or *Copper Glance*, we conclude that the prism of 119° in these species, parallel to faces of which the composition takes place, is the true vertical prism, as in Aragonite. The fact that $120° \times 3$ or $60° \times 6$ equals 360°, is evidently the fundamental reason for the occurrence of such twins; and hence in other species a like angle for the vertical prism, especially if the prisms are alike in their other dimensions, would be likely to produce the same result.

Hence we conclude that the sulphates (RO, SO^3), although affording in one direction a prism near 120° in angle, have not this prism as the fundamental vertical prism, for stellate composition, does not occur parallel to it; the true vertical prism is the one usually so assumed—that of 101° to 104°.

Bournonite affords another illustration of this subject. G. Rose has assumed its homœomorphism with Aragonite, on the ground that it has a vertical prism of 115° 58′. But this species, instead of forming twins parallel to the faces of this prism, actually affords cruciform twins parallel to a prism of 93° 40′, the one usually taken as the fundamental prism. The prism of 115° 58′ is $i\,\frac{3}{2}(\infty P\,\frac{3}{2})$ and there is no reason for regarding it as other than a secondary prism.

Chrysoberyl has been placed near chrysolite by the author, and also by M. Scacchi, of Naples. In a certain position the resemblance in angle exists. But still the species are rather widely remote, inasmuch as the twins, like those of Aragonite, parallel to faces of the prism of 119° 46′, show that this is the fundamental prism. Chrysolite affords no such twins; the angle of its vertical prism is 94° 3′, and it belongs to a different zone. Chrysoberyl is actually near Aragonite in angle; it has a brachydome of 108° 26′, and Aragonite one of 109° 39′.

Monoclinic prisms near 120° in angle, never present stellate twins like trimetric prisms. Such twins in oblique forms appear to be impossible, since they require a regular symmetrical character in the molecule above and below the middle section. This remark appears to apply also to hemihedral forms of the trimetric system, like those of datholite.

3. *General Habit of Crystals.*—A resemblance in general habit is often to be detected between species related in crystallization. Thus Brookite, as figured in this Journal, vol. xvii, p. 86, resembles Columbite in the general arrangement of its planes; and we

cannot mistake, in comparing them, as to the homologous prisms of the two. Again, it requires but a glance at the forms of feldspar and pyroxene to see that the habit here is wholly opposed to any homœomorphism between the species, while the family resemblance among the feldspars themselves is very striking.

4. *Frequency of Occurrence of Planes, or Zones of Planes.*— This criterion is sometimes of importance, and still it is very likely to lead astray. It is the common principle on which crystals are mathematically described, for that is usually assumed as the fundamental form which will give the simplest mathematical view of the crystallization. But it is well known that in many species *secondary* forms are most common. In Quartz, the fundamental form is rarely seen; in Calcite, the rhombohedron $-\frac{1}{2}R$ and scalenohedron R^3, are of far more frequent occurrence than R; in fluor, cubes are more common than octahedrons, the cleavage form; and octahedrons, when they occur, often have their surfaces made up of the angles of minute cubes; and the same is true of many species. It is consequently no certain evidence, when a prism terminates in a pyramidal summit (as in mesotype), that it is the unit pyramid, or even that the occurring prism in a species is one of the three unit prisms. It is natural to assume that an occurring zone of planes is one having the simplest ratios, and that among them exists one having the axial ratio of unity, $1a:1b:1c$. But this may be far otherwise. Anhydrite is a familiar example. The occurring prisms, according to the view of the author,* are $\frac{3}{3}\breve{i}(\frac{3}{3}P\,\overline{\alpha})$ and $\frac{3}{1}\breve{i}(\frac{3}{1}P\,\overline{\alpha})$, which bring out well the homœomorphism of the species with the other allied sulphates; but the three octahedral planes are then $\frac{3}{4}\breve{\frac{9}{5}}$, $\frac{6}{4}\breve{\frac{1}{8}}$, and $\frac{9}{4}\breve{\frac{7}{8}}$; and in any other view that recognizes the homœomorphism, the expressions for the planes are scarcely less complex.

We cannot be too guarded, therefore, when deducing the form for comparison with another species, in relying on the prevalence of certain planes. Valuable hints are often thus given, but they may lead to error.

The lustre or smoothness of planes is a better guide, though far from certain. The fundamental vertical prism in Barytes is generally less highly polished than many other faces; and as we have above remarked, the octahedrons of fluor have often rough surfaces.

The prevailing direction of the more extended zones of planes, especially the octahedral, often suggests rightly which is properly the terminal plane of the prism, these zones rising towards that plane; and they thereby afford a hint as to which is the vertical axis. In dimetric and hexagonal species, this criterion is a sure

* Am. Jour. Sci., [2] 17, 88.

guide (except sometimes in hemihedral forms); but here it is not needed, as the basal plane is fixed from the nature of the prism. The principle holds true for topaz and many trimetric species. In the rhombic octahedron of sulphur, in which either axis might be made the vertical, the *apical* angles, in which the true vertical axis terminates, are at once distinguished in modified crystals, by the cluster of planes about them. But the ambiguous cases are numerous, and this criterion, like others, is not an unfailing reliance.

When we may succeed in fixing upon the vertical axis in a species, and also the unit vertical prism, it is often difficult to determine which planes about the base should be taken as the unit domes or octahedron; and often there is a choice between two or three planes equal in lustre and size; and consequently it may be altogether doubtful whether the vertical axis equals $1a$, $\frac{1}{2}a$, or $\frac{2}{3}a$. Crystallographers may take whichever is most convenient without any important objection. But when looking to homœomorphous comparisons, it is important that the special claims of each should be duly considered, instead of blindly adopting those which authors have found best to serve them in their mathematics.

5. *Analogies derived from Relations in Composition and Form.*—Similarity in chemical composition has long been known to suggest similarity in crystallization; and among species thus related it is usually safe to assume that prisms approximate in angle are homologous. Other more indirect analogies are often of weight, as illustrated in the case of Leadhillite, in a paper by the writer, on page 210, vol. xvii, of this Journal. We there see that the sulphates and sulphato-carbonates are parallel throughout in their homœomorphisms, and we ascertain with much probability which is the fundamental vertical prism in Leadhillite.

6. *Values and Relations of the Angles of Forms.*—In the series of prisms in each axial direction, the vertical, macrodiagonal, and brachydiagonal, the planes, as is well known, have simple axial ratios, and the more common ratios are 1 : 1, 1 : 2, 2 : 3. If but a single prism occur in either direction, it is easy to calculate the values of the angles of other prisms having the above mentioned relations. This gives a series of angles. If, then, two species correspond nearly with one another in one element of such a series, they are also related in others, and they are evidently related in form. From the exceptions to the several criterions mentioned, it is evident that the absolute relation of the axes may not in many cases be ascertainable. The vertical axis, for example, may be doubled in length without violating any principle that can be laid down; or it may be halved in the same way. But we may with certainty determine whether forms are

related in the *series* of angles, and when so related, the species are in a correct sense homœomorphous. Augite and Hornblende may be regarded as differing in this way, as we can by no criterion decide that the lateral molecular axes of Hornblende and Augite are identical; we know that they are so related that one form might be a secondary to the other,—that the prism of hornblende has its orthodiagonal twice that of augite in length, and that the serial relation of the forms is such that they may be said to belong to one type. This point will be abundantly illustrated beyond. We observe that in all the comparisons made in the following tables, the only changes from the forms assumed by authors made on the above principles to exhibit the homœmorphism of species, are such as depend on the simple ratios, 1 : 2, 2 : 3, 3 : 2, 2 : 1. No torturing of the forms has been required by employing unusual or complex ratios, notwithstanding the hypothetical manner in which the received fundamental forms have been in many cases assumed.

The preceding are some of the methods that are of importance in determining the crystallographic homologies of species. It appears that the *first* point to be determined, is the true vertical axis of species under comparison; and this being ascertained, the *second* is to fix upon the fundamental or unit vertical prism, or that which shall give the relative values of the lateral axes; and *third*, we have to determine upon a unit dome, either a macrodome or brachydome, in a trimetric species, or else the unit octahedron, in order thereby to ascertain the true value of the vertical axis; and *fourth*, to make out the serial relations of forms, for a full comparison where the actual relations of the axes may be doubtful.

While studying forms by the above methods, it is also of interest to compare them as a whole without reference to which is the vertical prism; and only by viewing them thus in every different light can we fully understand their actual dimensional relations. In this point of view, the results of Hausmann respecting the anhydrous sulphates and carbonates are highly interesting, although secondary in importance to comparisons between the forms when placed in homologous positions.

The position of the vertical axis derives special importance from the crystallogenic nature of molecules. In a trimetric molecule, if we suppose three crystallogenic axes, a vertical and two lateral, while the vertical is at right angles to the lateral, from the nature of the form, the lateral may either intersect at right angles, corresponding to the form of a rectangular prism, or at oblique angles, corresponding to the angle of a rhombic prism; that is, in other words, they may connect the centres of the lateral faces of a rectangular prism or of a rhombic prism. Either condition will express the forces as indicated by the form, and result in the

solids of the trimetric system. And when the cleavage prism is rhombic, there is better reason for regarding the lateral axes as oblique in their intersections, than rectangular. The subject of twin crystals affords evidence that this is not mere hypothesis;* and additional proof is shown beyond in the relations of the domes to the angles of the regular octahedron. And still another argument may be derived from the relations of the domes in angle to the vertical prism. If such views may be adopted, it must obviously be essential to correct comparisons of form between species, that the *vertical* axis should be determined on the best possible data.

The preceding remarks are offered as introductory to the following tables of the values of the axes and principal prisms in trimetric mineral species. I have endeavored to apply with fidelity the principles that have been briefly reviewed. The unit prisms, as has been stated, are not in all instances those assumed as such by other authors; but although they are in general well entitled to be so regarded, they are not all supposed to be the unit prisms, as has been explained by referring to Hornblende and Augite as examples. An exhibition of the mathematical relations of the forms is the main point in view. Whenever we have placed in the columns of unit prisms, angles usually regarded as those of other prisms, it is stated by a mention of the form to which they have been commonly referred. Thus, under Chrysolite, the prism taken as $1\bar{\imath}$ is $\frac{1}{2}\bar{\imath}$ of most writers, as mentioned. These forms, as observed, differ from the unit prisms, either by the ratio 1 : 2 or 2 : 3, ratios of the simplest kind.

The trimetric species are naturally divided into *four* grand groups, differing in the angle of the fundamental or unit vertical prism (angle $I : I$ of the tables, $\infty P : \infty P$ of Naumann), as follows:—

1. Angle $I : I$ from $90\frac{1}{2}°$ to $95°$.
2. Angle $I : I$ near $102°$, or from $98°$ to $105°$.
3. Angle $I : I$ near $110°$.
4. Angle $I : I$ near $120°$.

It will be shown that these specific values of the angle $I : I$ are dependent on a principle of the most fundamental character. The *third* Group may however belong with the *second* as remarked upon beyond.

The angles mentioned in the table are the obtuse angle of the prism $I : I$ (column 1), and the summit angle of the unit macrodome and brachydome ($1\bar{\imath}$ and $1\breve{\imath}$ or $P\,\bar{\infty}$ and $P\,\breve{\infty}$).†

* See the author's Treatise on Mineralogy.

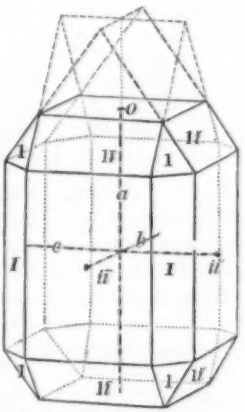
† To avoid any ambiguity in the angles referred to in the following pages, and render the subject intelligible to those who may not be familiar with crystallographic language, a few explanations are here given. The annexed figure represents

TABLE I.

Angle of Vertical Prism near 90°.

	Vertical Prism. $I : I$	Macrodome. $1\breve{1} : 1\breve{1}$	Brachydome. $1\breve{1} : 1\breve{1}$	Axes. $a : b : c$
I.				
Thomsonite,	90° 40′	108° 18′	108° 56′	0·72253 : 1 : 1·0117
Mesotype,	91°	(2$\breve{1}$)108° 46′	(2$\breve{1}$)109° 42′	0·71644 : 1 : 1·0176
Harmotome,	91° 46′	108° 48′	110° 26′	0·71626 : 1 : 1·0312
Wöhlerite,	90° 54′	108° 2′	108° 56′	0·7261 : 1 : 1·01583
Pyrolusite,	93° 40′	104° 22′	($\frac{1}{2}\breve{1}$)107° 54′	0·77601 : 1 : 1·0661
Andalusite,	90° 44′	109° 6″	109° 50′	0·71198 : 1 : 1·0129
Lievrite,	($\frac{1}{2}$)91° 32′	111° 14′	112° 40′	0·68429 : 1 : 1·0271
Staurotide,	($\frac{1}{2}$)93° 8′	($\frac{1}{2}\breve{1}$)108° 12′	111° 10′	0·72388 : 1 : 1·05617
Wavellite,	($\frac{1}{2}$)90° 34′	(2$\breve{1}$)106° 14′	106° 46′	0·75047 : 1 : 1·0099
Olivenite, Libethenite,	92° 30′	108° 28′	110° 50′	0·72034 : 1 : 1·0446
Caledonite,	95°	($\frac{1}{2}\breve{1}$)105° 8′	($\frac{1}{2}\breve{1}$)109° 54′	0·76568 : 1 : 1·0913
Chondrodite,	94° 26′	($\frac{1}{2}\breve{1}$)106° 52′	($\frac{1}{2}\breve{1}$)111° 4′	0·74176 : 1 : 1·0805
Antimony Glance,	90° 45′	($\frac{1}{2}\breve{1}$)109° 26′	($\frac{1}{2}\breve{1}$)110° 8′	0·6901 : 1 : 1·0132
Do. do.	90° 45′	(1$\breve{1}$) 88°	(1$\breve{1}$) 88° 47′	1·0352 : 1 : 1·0132
Polycrase,	95°	(1$\breve{1}$) 88° 30′	(1$\breve{1}$) 93° 53′	1·02655 : 1 : 1·0913
II.				
Epsomite,	90° 34′	120° 4′	120° 33′	0·57657 : 1 : 1·01
Diaspore,	93° 52′	115° 16′	118° 42′	0·63398 : 1 : 1·0699
Göthite,	94° 52′	113° 6′	117° 30′	0·66063 : 1 : 1·0888
Polianite,	92° 52′	115° 26′	118°	0·6317 : 1 : 1·0513
Euchrolite,	92° 8′	117° 20′	119° 13′	0·6088 : 1 : 1·038
Topaz,	($\frac{1}{2}$)93° 8′	($\frac{1}{2}\breve{1}$)115° 22′	($\frac{1}{2}\breve{1}$)118° 10′	0·63258 : 1 : 1·05617
Chrysolite,	94° 3′	($\frac{1}{2}\breve{1}$)115° 36′	($\frac{1}{2}\breve{1}$)119° 12′	0·6297 : 1 : 1·0733
Triphyline,	94°	($\frac{1}{2}\breve{1}$)118° 27′	($\frac{1}{2}\breve{1}$)121° 55′	0·59549 : 1 : 1·0724
Bournonite,	93° 40′	($\frac{1}{2}\breve{1}$)115°	($\frac{1}{2}\breve{1}$)118° 14′	0·63745 : 1 : 1·0662
Do.	"	(1$\breve{1}$) 92° 34′	(1$\breve{1}$) 96° 12′	0·95618 : 1 : 1·0662
? Warwickite,	93°–94°			
? Lanthanite,	93° 45′			

a rectangular prism with replaced edges and angles, and the three axes a, b, c. O is the basal plane of the prism; $\breve{1}$ the larger lateral plane, parallel to the *longer* lateral axis, or macrodiagonal, c; $\breve{1}$ the smaller lateral plane parallel to the *shorter* lateral axis, or brachydiagonal, b. I are planes on the vertical edges of the rectangular prism, which when extended so as to meet one another, would form a vertical rhombic prism, having its axes b, c, in the ratio of $1b : 1c$. It is therefore the *unit* or *fundamental* vertical prism. $1\breve{1}$ are planes parallel to the longer lateral axis, c, having for the axes a, b, the ratio $1a : 1b$; extended upward they form a *dome*, called the *macrodome*. The planes $1\breve{1}$, in a similar manner, constitute a *brachydome*, or dome parallel to the *shorter* lateral axis, and having the ratio $1a : 1c$. These two domes are therefore the *unit* domes. The planes 1 on the eight angles are planes of an octahedron, having for the axes a, b, c, the ratio $1a : 1b : 1c$; it is therefore the *unit* octahedron.



Taking axis $b = 1$, $c =$ tangent of half the angle $I : I$; and $a =$ cotangent of half the summit angle $1\breve{1} : 1\breve{1}$. These two angles alone are a correct exhibition of the degree of homœomorphism between species; all other angles are dependent upon these, and there-

The preceding table is naturally subdivided into two sections:

I. Species having the summit angles of the domes, near 109°.
II. Species having the summit angles of the domes, near 120°.

In the first of these groups there is a remarkable closeness of coincidence to the angle mentioned; and in the second, the variation from 120° in the brachydome is but small. The vertical axis typical of the groups differs therefore theoretically as $\sqrt{3} : \sqrt{2}$, which is nearly as 6 to 5.

In section I, the axes *a*, *b*, *c*, have nearly or typically the ratio $1 : \sqrt{2} : \sqrt{2}$. In Andalusite, the ratio is almost identical with this, and 109° 28′ is exactly a mean between 109° 6′ and 109° 50′, the angles given for the two domes.

In section II the ratio of the axes approaches $1 : \sqrt{3} : \sqrt{3}$, which it is very closely in Epsomite, the domes of which are nearly 120°.

109° is approximately the angle of the regular octahedron, the faces of which solid incline to one another 109° 28′. Moreover the angle of the vertical prism *I* varies but little from that of a cube, or 90°. Here is an obvious relation to monometric forms not to be overlooked. Moreover, the angle 120°, in section II, is the angle of the dodecahedron.

In the change, therefore, in a case of dimorphism, from the monometric to these trimetic forms, the characteristics of the monometric molecule, or form, are to a considerable degree retained.

It is to be observed that the domes $2\breve{1}$ and $2\check{1}$ for the same species afford nearly the angle 71°, the supplement of 109°; in fact, 109° 28′ for $1\breve{1}$ would give precisely the supplement 70° 32′ for the summit angle of $2\breve{1}$. In several of the species the occurring dome is that of 70°–71°, instead of that of 109°; so that either might be taken as characteristic of the first section in table I. 70° 32′ is the summit angle of the regular octahedron.

If, therefore, we compare the regular octahedron with the *rectangular* octahedron that would result from the united domes $2\breve{1}$ and $2\check{1}$ in the species of section I, we find them nearly identical. We observe, further, the important fact, that *the axes of the regular octahedron correspond to diagonals between the apices of the basal angles of the rectangular octahedron.* But these axes in the latter solid, cross at *oblique angles* equal to the angle of the rhombic prism *I*, instead of at right angles; and they correspond to lines between the centres of opposite lateral faces of the rhombic

fore a long series, for the sake of comparison although often given, is not necessary or even desirable.

As $1\breve{1}$ is the unit macrodome, so $2\breve{1}$ will be a macrodome with the vertical axis *twice* as long; $\frac{3}{2}\breve{1}$, one *two-thirds* as long; $\frac{1}{2}\breve{1}$, one *half* as long; and so on. The first figure or letter in a symbol refers always to the vertical axis *a*, and the other to the *longer* or *shorter* lateral axis, according as it has over it the long or short mark, ¯ or ˘.

prism, *I*, and not to those between the centres of its opposite lateral edges. In other words, these lines are not the *crystallographic* axes of the Trimetric system, but what the author has called the *crystallogenic* axes. This is one reason alluded to on a preceding page for believing that the crystallogenic axes are not necessarily the same lines with the crystallographic. The latter are lines assumed for the convenience of calculation.

If instead of the domes $1\breve{i}$ in section I, the species had afforded $\frac{3}{2}\breve{i}$ as common and dominant forms, and these were taken as the unit domes, then the unit octahedron, in place of the domes, would have the pyramidal angles near 109°, approaching those of the regular octahedron. Could we therefore assume this as the fundamental octahedron for the species, the derivation of the octahedron from the regular octahedron would be a change in the lengths only of the axes, and not in their angles of intersection. But this assumption would do violence to the facts. Still in Antimony Glance, we have an example probably of this form and mode of derivation; the dominant form is an octahedron, with the pyramidal angles 109° 16′ and 108° 10′, and basal 110° 58′. Bournonite and Polycrase may be other examples of a similar nature, though diverging more in their angles.

Although the two sections are strongly marked in the above table, still the species of one may be regarded as homœomorphous with those of the other. Thus Chrysolite of Group II, and Chondrodite of Group I, have been recognised by Scacchi as homœomorphous. So also Andalusite and Topaz are essentially homœomorphous, as well as similar in chemical formulas. In both of these cases, one of the species contains fluorine, and this is evidently the occasion of the wide divergence. Yet in one instance the fluorine species (chondrodite) belongs to section I, and in the other (topaz) to section II.*

The table affords examples, also, of the principle stated on a preceding page, that homœomorphous species, while identical in the particular axis which is the vertical, may vary by a simple ratio (1 : 2 or 2 : 3) in the axes, and that they are to be recognised as species that belong to a specific system of ratios, rather than to definite and identical dimensions.

Andalusite, Staurotide, and Topaz, have this relation. The forms of these species may be referred to a similar type; yet we cannot affirm that the axes have the near identity presented in the table, rather than a multiple ratio of 1 : 2 in some of the axes; we only know that they pertain to a common series.

Staurotide alone offers a choice between three uncertainties. The occurring form is a prism of 129° 20′ and this is usually

* The evidence as to the isomorphism of oxygen and fluorine, as shown by the relations of Andalusite and Topaz both in form and composition, were first pointed out by the author in vol. ix, p. 407, 2nd Series, of this Journal, and afterwards in his Mineralogy, 3d edition, 1850, p. 366.

taken as the unit vertical prism. A prism with the longer lateral axis *half* as long, has the angle 93° 8′, and this approaches the prism of Andalusite; and as the frequency of occurrence of a plane is no sure proof that the plane is necessarily of the fundamental series, we may with some reason assume the prism of 93° 8′ to be the fundamental one. But Staurotide forms twins in two directions, or parallel to two planes, and neither of these planes, referred to the above fundamental forms, has a simple ratio or expression, and this, notwithstanding the general fact that the faces of composition are of the highest value in ascertaining the directions of axial sections: moreover, one of the planes has the unusual symbol $\frac{3}{2}\breve{3}\frac{3}{2}$ if referred to the prism of 129° 20′, and $\frac{3}{2}\breve{\frac{3}{4}}$ if referred to that of 93° 8′. Now, if instead of halving the longer lateral axis, we take *two-thirds* for the new axis *c*, then the expression is of the simplest kind in every respect. The following are the angles and symbols of the planes according to these three methods:—

	$a : b : c$
A.—Prism $I = 129° 20′$; $1\breve{3} = 69° 16′$; $\frac{3}{2}\breve{3}$ (one face of composition) $= 88° 24′$; $\frac{3}{2}\breve{\frac{3}{2}}$ other face of composition.	1·4478 : 1 : 2·11233
B.—Prism $I = 93° 8′$; $2\breve{3} = 69° 16′$; $\frac{3}{2}\breve{3}$ (one face of composition) $= 88° 24′$; $\frac{3}{2}\breve{\frac{3}{4}}$ other face of composition; $1\breve{3} = 108° 12′$; $1\breve{3} = 111° 10′$.	0·7239 : 1 : 1·05617
C.—Prism $I = 109° 14′$; $1\breve{3} = 69° 16′$; $1\breve{3}$ (one face of composition) $= 88° 24′$; 1 other composition face.	1·4478 : 1 : 1·40822

In the last, the planes, and the faces of composition have all a unit ratio, and it affords the simplest possible view of the crystallization. Whether regarded as the fundamental form or not, the relation to andalusite is shown by the fact of the two belonging to one and the same series or system of ratios.

Topaz has $I : I = 124° 19′$ and $55° 41′$, and $i\breve{2} : i\breve{2} = 86° 52′$ and $93° 8′$. The two prisms might either be taken as the fundamental, with nearly equal propriety. If the first be so taken, and the macrodome of $58° 31′$ be the unit one, the axes are $a : b : c = 1·89774 : 1·05625 : 2$ $(= 1·7587 : 1 : 1·8936)$, a being treble what it is in Table I, and b double, the b also becoming c or the longer lateral axis. If the unit macrodome is that of $96° 2′$, the axes are the same except that a is half as long.

Lievrite is usually considered as having for its fundamental vertical prism, a prism of 111° 12′. Now this angle is near 109° 14′ for Staurotide, (type C); and taking $i\frac{3}{2}$ as the vertical prism *I*, the angle is near that of Andalusite. Moreover the species has near relations in its domes to the species of Table I, and none to those of Table III. Besides, in composition it resembles Andalusite and the allied species, in having less oxygen in its silica than in its bases. These facts afford some reason for placing the species where it stands in Table I.

The following are notices of other species in Table I:

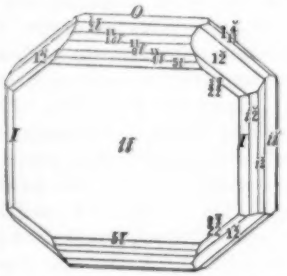
Chondrodite has for the summit angle of $1\breve{i}$, in its three types, 68° 32, 64° 54′, 70° 29′, giving as the mean 67° 58′, from which the mean for $\frac{1}{2}\breve{i}$ (taken as $1\breve{i}$ in the table) is 106° 52′, and the extremes 103° 28′ and 109° 26′. The angle for $1\breve{i}$ in the New Jersey chondrodite is 68°. The great difference of angle for these varieties of a single species should be considered, when judging upon the differences among the several species in the table. Taking $1\breve{i}$ above as the unit dome, the vertical axis is twice that given in the table, or 1·48352. In *Chrysolite*, also, we have as good reason for doubling the vertical axis, in which case it becomes 1·2584. In *Caledonite*, the occurring brachydome has the angle 70° 57′, and taking this as a unit dome, axis $a=$ 1·53136.

The relations of *Polianite* to Göthite and Diaspore appear to sustain the conclusion of Volger, cited in the American Journal of Science, vol. xvii, p. 213.

Euchroite is generally placed in a different position, and the prism 117° 20′ (form $1\breve{i}$) is made the fundamental vertical prism. But it forms no stellate or hexagonal twins like species of that angle, and nothing appears to sustain that view in preference to the one above taken.

Bournonite has the same relation to the species of Section II, that Antimony Glance has to those of Section I. It has very nearly the angles of Topaz.

Wöhlerite has quite recently been studied by the able crystallographer of Paris, M. Descloizeaux.* He gives for the vertical prism, the angle 108° 56′. But by comparing the range of angles with those of the above species, it appears that its true relations are exhibited by the position in the annexed figure, which is altered from Descloizeaux. This gives for the vertical prism, the angle 90° 54′, and for the unit domes, the angles 108° 2′ and 108° 56′, very near Andalusite. It appears to be generally true that when a species affords for the prisms of two axes, angles (measured over the extremity of the other axis) nearly alike, this other axis is the true vertical, and the vertical prism is near 90° in angle.



Polymignite is near Wöhlerite in its crystallization. With the fundamental form adopted, the known octahedron is $2\breve{2}$ ($2\breve{P}2$), and the occurring prisms are $1\breve{i}=109°\ 46'$, $2\breve{i}=70°\ 50'$, $4\breve{i}=39°\ 9'$.

Polycrase affords angles in three directions near 90°, whichever position be taken. In the figure annexed, the position and lettering cor-

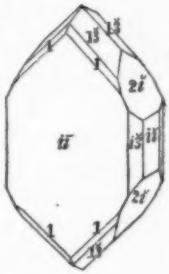
* Ann. de Chim. et de Phys., vol. xl, 3d series.

respond to the dimensions given in the table. Should we change it, and make the brachydiagonal the vertical axis, then :

$$I = 93° 52', \; 1\breve{i} = 91° 29', \; 1\dot{i} = 95° 2'.$$

And, again, if we make the macrodiagonal the vertical axis :

$$I = 91° 29', \; 1\breve{i} = 84° 58', \; 1\dot{i} = 86° 8'.$$



The symbols of these planes in these three positions (which we may call A, B, C,) are as follows :

A (figure)	1	$1\bar{3}$	$2\breve{i}$	$\breve{i}\breve{i}$	$\dot{i}\bar{3}$	$\dot{i}\dot{i}$	
B	1	3	$\dot{i}\bar{2}$	O (base)	$3\dot{i}$	$\dot{i}\breve{i}$	
C	1	$1\bar{3}$	$\frac{1}{2}\breve{i}$	$\breve{i}\breve{i}$	$\frac{1}{3}\dot{i}$	O	(base)

The form is near that of Bournonite. It is also related distantly to the Columbite species, the prominent difference being *five degrees* in the angle of the vertical prism.

The species of Table II. fall into four sections, depending on the angles of the unit domes.

TABLE II.

Angle of the Vertical Prism I near 102°.

	Prism *I.*	Dome $1\breve{i}$.	Dome $1\dot{i}$.	Axes $a : b : c$.
I.				
Valentinite,	($\frac{1}{2}$) 103° 30′	58° 17′	70° 32′	1·7934 : 1 : 1·2683
Heavy Spar,	101° 40′	63° 40′	74° 36′	1·6107 : 1 : 1·2276
Anglesite,	103° 38′	62° 42′	75° 29′	1·6415 : 1 : 1·2715
Leadhillite,	103° 16′	60° 20′	72° 34′	1·7205 : 1 : 1·2632
Celestine,	104° 2′	62° 39′	75° 52′	1·6432 : 1 : 1·2807
Anhydrite,	102° 56′	61° 25′	72° 38′	1·6836 : 1 : 1·2557
Tantalite,	101° 32′	($2\breve{i}$) 64° 7′	($2\dot{i}$) 74° 58′	1·5967 : 1 : 1·2247
Mascagnine,	107° 40′	65° 52′	83° 6′	1·5437 : 1 : 1·3680
Atacamite,	97° 2′	67° 40′	74° 20′	1·4919 : 1 : 1·1310
Sulphur,	101° 58′	($\frac{2}{3}\breve{i}$) 65° 18′	($\frac{2}{3}\dot{i}$) 76° 40′	1·5606 : 1 : 1·2342
"	"	($1\breve{i}$) 46° 16′	($1\dot{i}$) 55° 36′	2·3408 : 1 : 1·2342
II.				
Orpiment,	100° 40′	73°	83° 30′	1·3511 : 1 : 1·2059
Dimorphine (I.),	98° 6′	75° 40′	83° 40′	1·2876 : 1 : 1·1526
" (II.),	100° 32′	74° 2′	84° 24′	1·3262 : 1 : 1·203
Epistilbite,	($\frac{1}{2}$) 100° 58′	($\frac{1}{2}\breve{i}$) 76° 50′	($\frac{1}{2}\dot{i}$) 81° 30′	1·4063 : 1 : 1·2121
Childrenite,	104° 14′	73°	87° 14′	1·3514 : 1 : 1·2853
III.				
Prehnite,	99° 56′	($2\breve{i}$) 89° 45′	99° 41′	1·0044 : 1 : 1·1904
Columbite,	100° 40′	86° 45′	97° 28′	1·0584 : 1 : 1·2059
Wolfram,	101° 5′	88° 6′	99° 13′	1·0337 : 1 : 1·2149
Mengite,	100° 28′	87° 24′	97° 54′	1·0463 : 1 : 1·2071
Brookite,	100°	83° 14′	93° 16′	1·1260 : 1 : 1·1918
Scorodite,	98° 2′	84° 40′	92° 43′	1·0977 : 1 : 1·1151
Hopeite,	101°	86° 38′	97° 40′	1·0607 : 1 : 1·2131
IV.				
Manganite,	99° 40′	114° 19′	122° 50′	0·6455 : 1 : 1·1847
Calamine,	103° 54′	116° 39′	128° 26′	0·6170 : 1 : 1·2776
Haidingerite,	100°	118° 32′	126° 58′	0·5945 : 1 : 1·1918
Brochantite,	104° 10′	($2\dot{i}$) 114° 29′	126° 41′	0·6434 : 1 : 1·2838
Cotunnite,	99° 46′	118° 28′	126° 44′	0·5953 : 1 : 1·1868
† Mendipite,	102° 36′			x : 1 : 1·2482
† Jamesonite,	101° 20′			x : 1 : 1·2203

I. Angle of macrodome near 60°, and brachydome near 71°.

II. Angle of macrodome 70° to 75°, or near the brachydome of Section I.

III. Angle of macrodome 83° to 90, or near the brachydome of Section II.

IV. Angle of macrodome 114° to 120°.

In Section I, the angles of the domes oscillate from or about the monometric angles 60° and 70° 32′. In Section III, 90° is nearly a mean between the angles of the domes. In Section IV, 120° is a similar mean for the domes. Section II is intermediate between I and III, the macrodome corresponding with the brachydome of Section I, and the brachydome with the macrodome of Section III. The vertical axis in Section III is *two-thirds* that of Section I; and by taking $\frac{3}{2}\bar{1}$ as $1\bar{1}$, the two groups would coalesce. The vertical axis of Section IV is about *two-fifths* of that of I.

In Section I, a macrodome of 60° and a brachydome of 70° 32′, both monometric angles, necessarily imply a vertical prism of 101° 34′. Hence the important fact, that *prisms approximating to* 101° 34′ *are of common occurrence, and a necessary result of the relations pointed out to Monometric forms.* This affords a sufficient reason for the occurrence of so many species near 102° in angle, just as there are many near 90°, and gives special importance to this value of $I : I$. Such prisms have approximately

$$a : b : c = 1 : \sqrt{\tfrac{1}{3}} : \sqrt{\tfrac{1}{2}}.$$

Valentinite affords an interesting exemplification of the general principle. Oxyd of antimony is a known example of dimorphism, occurring in *regular octahedrons* as *Senarmontite* and in *rhombic prisms* as *Valentinite.* It would hardly be expected that the latter should retain closely any of the angles of the former; and yet there is a brachydome having exactly the angle 70° 32′. The cleavage vertical prism has the angle 136° 58′, which gives for the prism with half the macrodiagonal, 103° 30′,—a relation like that between hornblende and augite. The three unit prisms, 103° 30′, 58° 17′, 70° 32′, very nearly correspond to the typical value of the axes $1 : \sqrt{\frac{1}{3}} : \sqrt{\frac{1}{2}}$.

It is of interest in this connexion to compare *Epistilbite* with Valentinite. It presents the vertical prism 135°, corresponding to 136° 58′ of Valentinite; and there is a macrodome of 109° 46′, whence another macrodome $2\bar{1} = 70° 50'$, or very nearly the angle of the brachydome of Valentinite. It gives for $i\bar{2}$ the angle 100° 58′, as mentioned in the table. The occurrence of these Monometric angles has, beyond doubt, a profound significance. We hereby perceive in what respect Section II is related to Sections I and III. The oscillations from the typical angles of the group amount to about 5°.

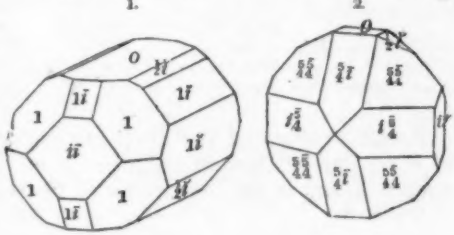
Other species in Table II require special remarks.

In *Sulphur*, the unit macrodome of authors has the summit angle 46° 18′. But taking $\frac{2}{3}\breve{1}$ as the unit dome, the angle is near that of Barytes and the other sulphates, as in the table; $\frac{1}{3}\breve{1}$ in sulphur is near $\frac{1}{2}\breve{1}$ in Barytes. *The homœomorphism of sulphur and the sulphates* (RO, SO^3) *is hence evident.*

Orpiment (sulphuret of arsenic) differs from sulphur in pertaining to Section II. The sulphur and arsenic compounds present a like amount of difference; and, further, they show that the fundamental vertical prism is that of 100° 40′, instead of that of 117° 49′, adopted by some authors. The difference in the unit domes of sulphur and orpiment is about $7\frac{1}{2}$ degrees, and the difference in the sulphurets and arseniurets or arseniosulphurets is nearly as large, or 5 to 6 degrees.

The arseniuret of iron (Leucopyrite or Lölingite) has been hitherto described as having a vertical prism of 122°, and the arsenio-sulphuret (mispickel) an angle of 112°, and the sulphuret (marcasite) of 106°. But the writer has been informed by R. P. Greg, Jr., that he has measured crystals of the arseniuret, and found the angle the same as for the arsenio-sulphuret. The difference of 6 degrees is, therefore, the full difference due to the arsenic; and where arsenic is present with sulphur in these compounds, the sulphur is wholly overpowered by the arsenic; just as in the sulphato-carbonates, the sulphuric acid dominates completely over the carbonic acid, the angle agreeing closely with that of the sulphates (anglesite), instead of being half way between those of the carbonates and sulphates.

Dimorphine, a sulphuret of arsenic of undetermined composition, falls into the same group with orpiment, and is near it in angle. Professor Scacchi, in describing dimorphine,* recognises the fact that it affords two angles approaching those of orpiment, viz. 83° 40′ and 117° 48′; and he adds correctly, that they do not, however, correspond in position in the two species. But on examining further his type I, and viewing the form in a different position, we find that there are two prisms, which taken as domes give the angles at summit 83° 40′ and 75° 40′ (angles $o : o$ and $e : e$ in Scacchi, pl. 12, f. 4, or $1\breve{}$ and $1\bar{i}$ in the annexed figure 1); and these angles are so near two domes in orpiment that we can hardly hesitate as to regarding this the right position for the figures. We here make B of Scacchi the terminal plane O; A, the plane $i\bar{i}$; C, the plane $\bar{i}\bar{i}$; also o^2 is $\frac{1}{2}\breve{1}$, and m is 1 or the unit octahedron. In Scacchi's type II (figure 2, above), the planes referred to the same fundamental form, are $\frac{2}{3}\bar{i}$ (e of Scacchi, fig. 13, pl. 4), $i\frac{5}{4}$ (i), $\frac{5}{4}\frac{5}{4}$ (m), $\frac{1}{2}\breve{1}$ (o^2).



* Memorie Geolgiche sulla Campania per A. Scacchi, Napoli, 1849, p. 120.

In this type, the angles, as given in the table, are almost identical with those of Orpiment. The axes become for

	$b=1$	$a=1$
Type I, $a:b:c$	$=1{\cdot}2876:1:1{\cdot}1526$	$=1:0{\cdot}77661:0{\cdot}89526$.
Type II, $a:b:c$	$=1{\cdot}3262:1:1{\cdot}2030$	$=1:0{\cdot}75405:0{\cdot}90707$.

The ratio $\frac{2}{3}$ in Type II loses its improbability, if any there be, when it is observed that *the domes of this ratio have approximately the angles of the unit domes of sulphur* or of the section to which sulphur belongs, they being $\frac{2}{3}\breve{\imath} = 62°\ 12'$ ($e:e$, f. 13, of Scacchi), and $\frac{2}{3}\breve{\imath}$ (not observed) $= 71°\ 56'$. They approach most nearly the unit domes of anhydrite.

Tantalite (FeO, TaO^3) has very nearly the dimensions of Barytes (BaO, SO^3), as seen in the table; and the fact is important, as it sustains the *homœomorphism of tantalic and sulphuric acids.*

Brookite was first observed to be homœomorphous with Columbite by Hermann. It differs by four degrees in its domes from that species, and has its vertical axis about one-twelfth longer.

In *Columbite*, it is of importance to note, that the face of twin composition is a plane of the brachydome $2\breve{\imath}$, in which the *basal* angle is about 120°; and in *Wolfram*, it is the brachydome $\frac{2}{3}\breve{\imath}$, in which the *summit* angle is about 120°.

Leadhillite has been shown by the writer to have close relations in angle to Anglesite, in this Journal, vol. xvii, p. 210. Its dimensions, as given in the table, exhibit still further this similarity of form. We reserve remarks on the forms of Leadhillite for another occasion.

Mascagnine diverges widely from the other sulphates in its vertical prism, and therefore also in its brachydome, while it agrees with them nearly in its macrodome.

We add a word on the unit-octahedrons of the species of Table II. The following are the angles for species in Sections I, III, and IV:

	Pyramidal Angles.		Basal Angle.
Section I.—Barytes, - - -	111° 38′	91° 22′	128° 36′
" Anglesite, - -	112° 13′	89° 41′	128° 54′
Section III.—Columbite, - -	117° 53′	102° 58′	107° 56′
" Brookite, - -	115° 42′	101° 34′	111° 26′
Section IV.—Manganite, - -	130° 49′	120° 44′	80° 22′
" Cotunnite, - -	133° 22′	123° 58′	75° 48′

It will be observed that there is an approximation to the angle of a regular octahedron only in one of the pyramidal angles of Section I, and in the basal angle of Section III.

TABLE III.

Angle of Vertical Prism, near 109° 28′.

	Prism *I.*	Dome *1̆i.*	Dome *2̆i.*	Axes $a:b:c.$
I.				
Marcasite, - - - - - -	106° 5′	64° 52′	80° 20′	1·5737 : 1 : 1·3287
II.				
Mispickel, - - - - - -	111° 53′	59° 14′	80° 8′	1·7588 : 1 : 1·4793
Leucopyrite, - - - - -	111° 30′			
Aurotellurite, - - - -	110° 48′	(2$\breve{\imath}$) 58° 52′	(2$\breve{\imath}$) 78° 34′	1·7723 : 1 : 1·4496

The angle of the vertical prism in Table III is near the angle of a regular octahedron (109° 28′). As this prism is a cleavage prism, and the only distinct one in the species, it appears to be the true vertical prism.

But if we give the species another position, we may exhibit a relation to Sections II and III of Table II; and as they are all related to the species of those sections in composition, this relation is of fundamental interest. Making the brachydome $1\breve{1}$ the vertical prism, then the angle given above for the verticai prism is the new macrodome, and the supplement of that for the macrodome is the new brachydome. This gives for mispickel the angles $I : I = 99° 52'$; $1\breve{1} : 1\breve{1} = 111° 53'$; $1\breve{1} : 1\breve{1} = 120° 46'$. If we now double the length of the vertical axis, the dome 111° 53′ becomes $\frac{1}{2}1\breve{1}$, and 120° 46′ $\frac{1}{2}1\breve{1}$; and the three angles will be

$$I : I = 99° 52'; \quad 1\breve{1} : 1\breve{1} = 72° 58'; \quad 1\breve{1} : 1\breve{1} = 82° 40',$$

which are almost identical with the angles in Orpiment. The following table presents the angles and axes of the species thus changed in position, and also those referred to on Table II.

TABLE III. A.

	Prism *I.*	Dome $1\breve{1}$.	Dome $1\bar{1}$.	Axes $a : b : c$.
I.				
Sulphur, - - - - - -	101° 58′	65° 18′	76° 40′	1·5606 : 1 : 1·2342
Marcasite, - - - - - -	99° 40′	67° 12′	76° 24′	1·5049 : 1 : 1·1847
II.				
Orpiment, - - - - - -	100° 40′	73°	83° 30′	1·3511 : 1 : 1·2059
Dimorphine (I.) - - -	98° 6′	75° 40′	83° 40′	1·2876 : 1 : 1·1525
do. (II.) - - -	100° 32′	74° 2′	84° 24′	1·3262 : 1 : 1·2030
Mispickel, - - - - - -	99° 52′	72° 58′	82° 40′	1·3520 : 1 : 1·1890
Aurotellurite, - - -	101° 26′	71° 52′	83° 6′	1·3797 : 1 : 1·2225

It appears from the table that *Marcasite*, $Fe S^2$, is very near Sulphur in its angles and axes; while *Aurotellurite* (Ag, Au), Te^2, and *Mispickel*, $Fe(S, As)^2$, to which *Leucopyrite*, $Fe As^2$, should be added, have the form nearly of Orpiment. It is a question, therefore, whether Table III should not be suppressed, and the species annexed to Sections II and III of Table II. The cleavage constitutes the main reason for regarding the species as a separate Group. But notwithstanding the peculiarity in this respect, the affiliation with Sulphur and Orpiment is undoubted.

In Table IV. we recognize four sections:

I. Angle of macrodome near 70° 32′.
II. Angle of brachydome near 109° 28′.
III. Angle of macrodome near 109° 28′.
IV. Angle of brachydome near 120°.

The vertical axis in Section II is about one-fourth shorter than in Section I; in the latter $\frac{3}{4}1\breve{1} = 85° 40'$, which approaches $1\breve{1}$ in the former, being very nearly the angle of Stephanite.

TABLE IV.

Angle of Vertical Prism, near 120° (115½°–120°).

	Prism *I.*	Dome 1̄2.	Dome 1̄1.	Axes *a* : *b* : *c*.
I.				
Sternbergite, - - - -	119° 30′	69° 38′	100° 2′	1·4379 : 1 : 1·7147
II.				
Aragonite, - - - - -	116° 10′	81° 40′	108° 26′	1·1571 : 1 : 1·6055
Cerusite, - - - - -	117° 13′	80° 19′	108° 16′	1·1852 : 1 : 1·6388
Witherite, - - - - -	118° 30′	77° 30′	106° 54′	1·2460 : 1 : 1·6808
Bromlite, - - - - -	118° 50′	77° 18′	107° 5′	1·2504 : 1 : 1·6920
Stephanite, - - - -	115° 39′	85° 5′	111° 8′	1·0897 : 1 : 1·5844
Nitre, - - - - - -	118° 50′	80° 16′	109° 57′	1·1861 : 1 : 1·692
Chrysoberyl, - - - -	119° 46′	(⅔1̄)78° 54′	(⅔1̄) 109° 38′	1·2152 : 1 : 1·7239
Discrasite, - - - - -	119° 59′	81° 22′	112° 12′	1·1633 : 1 : 1·7315
Copper Glance, - - } Stromeyerite, - - }	119° 35′	(⅓1̄)83° 56′	114° 10′	1·1117 : 1 : 1·7176
III.				
Herderite, - - - - -	115° 53′	111° 42′	133° 58′	0·6783 : 1 : 1·5971
IV.				
Iolite, - - - - - -	119° 10′	94°	121° 38′	0·9325 : 1 : 1·7033
Mica, - - - - - -	119°–120°			

Chrysoberyl is very near Aragonite in angle, if the plane in the former usually regarded as ⅔1̄ be taken as 1̄1̄, as adopted in the table: otherwise the relation for the vertical axes of the two species is that of 3 : 2. So also *Copper Glance* approaches Aragonite, if what has been taken by authors as ⅔1̄ be regarded as 1̄1̄; otherwise the relation between them is that of 2 : 3. Such ratios, as we have elsewhere remarked, and the tables everywhere illustrate, are consistent apparently with homœomorphism in species. We have not sufficient data, at present, to decide whether the relation between Aragonite and Copper Glance is actually that of 1 : 1 or of 2 : 3, yet are inclined to believe the latter the fact; and if so, 1̄1̄ in Copper Glance has 61° 54′ for the summit angle, and 118° 6′ for the basal; the latter angle is near that of the vertical prism.

Many of the species in Tables II and III afford a horizontal prism or unit dome of 115° to 120°; and consequently, if this dome were taken as the fundamental vertical prism, the species would pertain to Table IV. Although we have not good reason for making the change, it is of some importance to view the species in this way, in order to apprehend more fully all the affiliations and relations of the forms. The author has alluded to Hausmann's comparisons by this method, of the anhydrous sulphates and carbonates; and he would here observe that the general review of Trimetric forms which he has made since his former paper was printed, and which has been here presented, has led him to give more importance to such comparisons than was implied in his paper in this Journal, vol. xvii, p. 210.

In the annexed Table the first column contains a statement of the particular dome in the preceding Tables which is here made the vertical prism; in some cases the angle of this prism is the supplement of that which is given for the dome in those Tables.

TABLE IV. A.

		Prism *I.*	Dome II.	Dome IV.
From Table I.				
Chrysolite,	II	115° 36′	60° 48′	85° 57′
Do.	II	119° 12′	64° 24′	94° 3′
Triphyline,	II	118° 27′	58° 5′	86°
Do.	II	121° 55′	61° 33′	94°
Epsomite,	II	120° 4′	59° 27′	89° 26′
Do.	II	120° 33′	59° 56′	90° 34′
Diaspore,	II	115° 16′	61° 18′	86° 8′
Do.	II	118° 42′	64° 44′	93° 52′
Göthite,	II	113° 6′	62° 30′	85° 8′
Do.	II	117° 30′	66° 54′	94° 52′
Polianite,	II	115° 26′	62°	87° 8′
Do.	II	118°	64° 34′	92° 52′
Euchroite,	II	117° 20′	60° 47′	87° 52′
Do.	II	119° 13′	62° 40′	92° 8′
Topaz,	II	(½) 115° 22′	61° 50′	86° 52′
Do.	II	(½) 118° 10′	64° 38′	93° 8′
Bournonite,	II	(½) 115°	61° 46′	86° 20′
Do.	II	(½) 118° 14′	65°	93° 40′
From Table II.				
Valentinite,	II	121° 43′	76° 30′	109° 28′
Barytes,	II	116° 20′	78° 20′	105° 24′
Anglesite,	II	117° 18′	76° 22′	104° 31′
Leadhillite,	II	119° 40′	76° 44′	107° 26′
Celestine,	II	117° 21′	75° 58′	104° 8′
Anhydrite,	II	118° 35′	77° 4′	107° 22′
Tantalite,	II	115° 53′	78° 28′	105° 2′
Mascagnine,	II	114° 8′	72° 20′	96° 52′
Sulphur,	II	(½) 114° 42′	78° 2′	103° 20′
Manganite,	II	114° 19′	57° 10′	80° 20′
Calamine,	II	116° 39′	51° 34′	76° 6′
Haidingerite,	II	118° 32′	53° 2′	80°
Brochantite,	II	114° 29′	53° 19′	75° 50′
Cotunnite,	II	118° 28′	53° 16′	80° 14′
From Table III.				
Marcasite,	II	115° 8′	73° 55′	99° 40′
Mispickel,	II	120° 46′	68° 7′	99° 2′
Aurotellurite,	II	121° 6′	69° 12′	101° 26′

Comparing the species in Table IV, A, with those of Table IV, we observe the following affiliations:

Marcasite and Aurotellurite are near Section I (Sternbergite).

From Valentinite to Sulphur (from Table II), are near Section II, (Aragonite Section).

From Chrysolite to Bournonite (from Table I), with also Manganite, are not coincident with either Section of Table IV, but they have approximately the ratio to the Aragonite Section of

4 : 3. This is the ratio between Chrysolite and Chrysoberyl. If 119° 12′ in Chrysolite be considered as corresponding to 119° 46′ in Chrysoberyl, then the macrodome of 64° 24′ in Chrysolite, if referred to the form of Chrysoberyl, would be $i\frac{1}{3}$.*

From Calamine to Cotunnite, the vertical axis is to that of the Barytes series nearly as 5 : 3.

In reviewing the Groups of Trimetric forms, the most prominent fact observed is the prevalent approximation in the values of the angles of the unit prisms, to the three monometric angles, 90°, 109° 28′, and 120°, or their supplements, 70° 32′, and 60°; above all, the angles approaching 109° 28′ and 70° 32′ much predominate. When the vertical prism is near 90°, domes near 109° 28′ and 70° 32′, characterize very many of the species; while domes near 120° belong to the rest of the species. And in the second great group, macrodomes near 70° 32′, and 109° 28′, and brachydomes near 60° and 120°, determine the vertical angle of the prism, which approaches 101° 36′. Another large group has 120° and 60° as approximately the angles of the vertical prism.

The fact that the axial ratios 1 : $\sqrt{2}$ and 1 : $\sqrt{3}$ are typical of certain groups has been mentioned. It is easy to make out, in many cases, simple ratios between the axes, or the sum of two of the axes and the third; but the importance that should be attached to such ratios is questionable. The following are a few examples:

	Axes a : b : c	
Epistilbite (I=100° 58′),	1·4063 : 1 : 1·2121	$a+b=2c$.
Calamine, - - - -	0·6170 : 1 : 1·2766	$2a=c$.
Brochantite, - - - -	0·6534 : 1 : 1·2838	$2a=c$.
Cotunnite, - - - -	0·5953 : 1 : 1·1868	$2a=c$.
Haidingerite, - - -	0·5945 : 1 : 1·1918	$2a=c$.
Göthite, - - - - -	0·6606 : 1 : 1·0888	$3a=b+c$.
Polycrase, - - - -	1·0265 : 1 : 1·0913	$2a=b+c$.
Valentinite, - - - -	1·7934 : 1 : 1·2683	$2a=b+2c$.
Sulphur ($1\bar{1}$), - - -	2·3408 : 1 : 1·2342	$a=b+c$.
" ($\frac{3}{2}\bar{1}$), - - -	1·5606 : 1 : 1·2342	$\frac{3}{2}a=b+c$.

In Valentinite this relation is evidently dependent on the more authoritative and equally exact ratio $a : b : c = 1 : \sqrt{\frac{1}{3}} : \sqrt{\frac{1}{2}}$.

Many conclusions bearing on chemical formulas, and the chemical relations of species, flow from the facts in the preceding tables. But we leave, for the present, that branch of the subject without further remarks.

* Since this paper was first printed, the author has found that M. Kengott of Vienna has recently pointed out similarities in the angles of Discrasite, Copper Glance, Antimony Glance, Bournonite, Chrysolite, Chrysoberyl, Tantalite, Topaz, Electric Calamine, Aragonite and Cerusite. But the true grounds of relation and distinction between these species, brought out in this paper, are not recognised.

ART. VI.—*On certain Physical Properties of Light, produced by the combustion of different Metals, in the Electric Spark, refracted by a Prism;* by DAVID ALTER, M.D., Freeport, Penn.

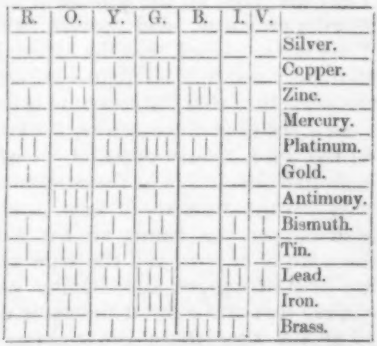
WE are indebted to the celebrated M. Fraunhofer for the fact, that the Solar Spectrum is crossed by numerous fixed lines, and that the light of some of the stars differs from that of the sun, in the number and situation of these lines.

In order to see some of these lines without the aid of a telescope, I ground a prism of flint glass, with large refracting angle, (74°). Viewing a fine slit made in sheet brass, when the source of light was the sky, nearly in the direction of the sun seen through this prism, I could count twelve or thirteen of Fraunhofer's dark lines. In viewing the blaze of a lamp, burning petroleum, I could discover neither dark nor bright lines, although I narrowed the light by passing it through the fine slit of sheet brass. I then tried the blaze of a tallow candle, when I could distinctly see an orange image of the blaze and one of faint yellow and one of green at the base of the blaze. The base of the orange image appeared to be the reflection of the light without any dispersion. When the brass with the fine slit is held in a horizontal position and the refracted light seen through it, is from the base of the blaze, bright bands, one of orange, one of yellow, one of green, one of blue, and one of violet, are seen.

The flame of alcohol is the same, except that the orange band is wanting. A slip of white paper shows the same bands when illuminated by a tallow candle. The jet of a blowpipe shows the five images still more distinctly.

The light from heated wire or charcoal shows no peculiarities. The electric spark from a Leyden Jar gave several bright images, which from optical illusion (perhaps from their brilliancy) appeared to extend beyond the sides of the spectrum, causing it to appear serrated along the edges.

But the most interesting effect of refraction, is from the spark caused by breaking the galvanic circuit, or at the break of a powerful magneto-electric machine. The machine I used produced sparks nearly half an inch in length. These sparks, viewed through the prism, appear almost wholly resolved into separate, colored bands, as illustrated in the annexed figure, where R is the red extremity of the spectrum, and V the violet.



Thus in the silver, there is in the orange a very bright band, one of yellow and one of green—two faint bands in the blue which are not always seen, and are probably caused by an impurity in the metal. The light which is not resolved into these bands is very faint except in the red.

The copper has two in the orange and three in the green—the other light appearing most distinct in the red and yellow. In the zinc there is a strong band of red, two of orange and three of blue with a faint yellow. The lead has two bright orange, and two in the yellow, nearer the orange than appears in the silver, then faint green bands and one bright violet, at the extremity of the spectrum.

Tin has a faint red, two of orange, three faint yellow, and a very faint green band, and also one of blue, indigo and violet.

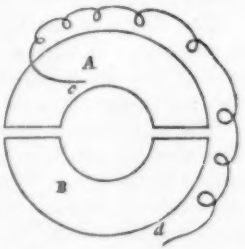
Iron exhibits a bright orange, four faint green, and sometimes two faint blue bands.

Bismuth a bright orange, a very faint yellow, two faint green, and a bright indigo.

Antimony some bright orange, and faint appearances in the yellow, green and blue.

Brass, a compound of copper and zinc, exhibits all the bands that are exhibited by these metals separately, i. e. one of red, one of orange, three of green, three of blue, one yellow and one indigo.

The preceding table presents these results, with some faint bands not above alluded to.



To illustrate better the manner of producing the sparks by the magneto-electric machine, I have annexed the following figure of the break. A and B represent two half circular discs of the metal intended to be used. One of these is connected with one end of the helix, and the other with the other end. They are fixed on the spindle of the revolving armature, and revolve with it. They are so placed, that the extremity *c* of the wire *c d*—which is stationary and rubs on them—is passed from the one to the other at the same time that the armature is passing the poles of the magnets.

In order to produce sparks, the end *d* of the wire is caused to rub on the discs, nearly opposite C—which causes a bright spark at each half revolution of the armature.

When the discs are of zinc, and the extremity *d* of the wire is of copper, the bands are the same as in brass, as also if the discs are of copper, and the wire zinc. When the discs and wire are both of copper, after having used a wire of zinc on the discs —they will still exhibit the same colored bands as the brass, until all the zinc left by the friction is removed, when the characteristic bands of the copper alone appear.

When silver and copper are used the bands are the same as with the silver alone, with the addition of two bands in the green, and so with any two metals, the bands are the same that both the metals exhibit when used separately, and the number of bands in the two metals will be equal to the number in both, except where they have bands that correspond in situation, in which case the bands of the two metals are blended together, producing bands of greater brilliancy. A spark between charcoal points does not show any peculiarity. The orange band appears to be common to all the metals tried—but I have not determined whether it occupies the same situation in the spectrum in all cases. The light of the spectrum not collected into the several bands, differs in intensity with the different metals—that with tin, iron and antimony being strong, while that of silver, copper and zinc, is faint.

ART. VII.—*Chinese and Aztec Plumagery;* by D. J. MACGOWAN, M.D.

THOSE natives of Northeastern Asia who in modern times have been drifted to the opposite shores of the Pacific were generally fishermen, mariners, or persons unacquainted with mechanical operations, and it is altogether probable that from the period of the first disaster by which they were driven to America, to that of the last shipwreck on that coast, very few artizans, and no scholars have in this manner changed continents; nor, judging from the low state of civilization of the more northern peoples, could it be expected that adventurers by the way of Behring's Straits or the Aleutian islands would carry with them a knowledge of any arts but the most simple and rudimentary. Hence, we shall look in vain for many resemblances in the industrial operations of the dwellers on the eastern and western coasts of the great ocean. Nevertheless, there is reason to believe that were we better acquainted with the state of arts amongst those farthest advanced in civilization in Polynesia and America, we should recognize modes of operation identical with those of China too numerous to be accounted for either as coincidences, or as independent inventions. A striking illustration is furnished by Capt. Wilkes,* who gives a drawing and description of an instrument for drilling holes, which he found in use by the inhabitants of Fakaafo or Bowditch island. This is undoubtedly a Chinese implement, being the most ingenious of all their tools. It is employed for perforating small holes by all workers in metals, but appears to most advantage in the hands of needle makers, who use it for drilling eyes in the small wires of which these are made.

* Narrative of the U. S. Exploring Expedition, by Capt. Wilkes, U.S.N., vol. v, p. 17.

Whether plumagery or the art of working in feathers, which was formerly practised in this part of the world, and also by the Aztecs of Central America, originated with Asiatics, or Americans, or with both, must be left to conjecture: in any view of the case, the fact is invested with interest. Attention was attracted to this subject by perusing the chapter devoted to an inquiry into Aztec civilization in Prescott's History of the Conquest of Mexico, where the distinguished historian shows that the ancient Mexicans excelled in the arts of plumagery and jewelry, in both of which they appear to have followed the same methods that are adopted by the Chinese.

Confucius informs us that in remote antiquity, ere the art of weaving silk or hemp was understood, mankind were clothed with the skins of beasts and feathers. How the latter were held together is not stated, but it must have been in a rude manner by cords or thread: at a later period feathers were in general demand as ornaments to banners and articles of attire; and subsequently for the manufacture of door-screens and caps. Tradition states that garments made of feathers and resembling fur dresses were presented to the emperor Shauhau, who reigned twenty-five centuries before our era. The earliest allusion to robes *woven* with feathers, occurs in the history of the Tsin dynasty. In the year 272 A. D., Dr. Ching, the court physican, presented the emperor with a gown made of feathers from the golden-headed pheasant. His Majesty being the founder of a new dynasty, was anxious to induce economical habits among his subjects; he therefore immediately ordered the splendid garment to be publicly burnt before the palace door, and issued on the following day stringent prohibitions against the presentation of articles of luxury.

The emperor Wuti, who flourished in the latter part of the fifth century, had a son who was notorious for his extravagance, having among other costly articles, a robe woven with peacocks' feathers. History further informs us that it was the custom of emperors to make presents every eleventh month of robes made out of the feathers of the variegated king-fisher to certain ministers of state. Taitsung, A. D. 976, changed the custom so far as to substitute silk for plumagery. Again, at a later period, the imperial records relate that the princess Ganluh engaged a skillful artificer to collect feathers of every description, to make of them two dresses, which should when looked at in front present one color, when viewed sideways another, and when held up to the light a third. When completed, she presented them to the empress, and they were so much admired that the fabric became very fashionable among officers and people, so much so that the hills and forests were swept clean of down and feathers, and vast numbers of birds were ensnared for their plumage.

More instances might be adduced to show that at different periods extending through many centuries plumagery was well understood. Garments thus manufactured were necessarily rare, their use being confined to persons of rank and wealth, and it may be doubted if even among the Aztecs whose country unlike China had vast forests crowded by the feathered tribe, the material was so abundant as to allow the inhabitants generally to shine in borrowed plumes.

The foregoing examples, drawn from the popular encyclopedias, throw no light on the mode of manufacturing this elegant material. Something however may be gathered on this subject from a work styled "New Conversations on things seen and heard at Canton," by a native of Suchau who spent many years in that city in a mercantile capacity in the latter part of the last century. In a short section devoted to *Bird Clothes*, he says, "There are several kinds of birds, the feathers of which are woven into a peculiar cloth by the southern barbarians. Among them is the celestial goose velvet, the foundation of the fabric being of silk, into which the feathers were ingeniously and skillfully interwoven, on a common loom, those of a crimson hue being the most expensive. Of these wild goose feathers, two kinds of cloth were made; one for winter, the other for summer wear. Rain could not moisten them; they were called 'rain satin,' and 'rain gauze' respectively. Canton men imitated the manufacture, employing feathers of the common goose, blending them with cloth. This fabric though inferior in quality was much cheaper. Goods of the same description were also brought from Hohlih [a state described by geographers as being adjacent to Samarcand, perhaps Bokhara] made of birds' feathers; they were twilled, the crimson colored being most valued. The article was too heavy for garments. The Cantonese also learned to imitate this, making it like plain silk, and inferior to that from abroad. Peacock feathers are employed by Canton manufacturers in making variegated threads which are used in making beautiful capes for females." Another writer states that a tribe of the Miaut, in Kwangsi, manufacture clothes from the fine down taken from the abdomen of geese. The down and tufts of birds were probably the materials which were woven into textile-like fabrics.

From the above, it would appear that the Chinese have lost the art of weaving feathers. Plumagery is still practised, however, in the decoration of metallic ornaments worn by all classes of females, chiefly on the head. When silver is employed, the article is first coated with gold. The gaudy lustre of the gilt is softened by laying over portions of it a covering of blue feathers representing flowers, insects, birds, and the like, which imparts indescribable beauty to the silversmith's elaborate filagrees. The art appears to most advantage as practised by artificers whose occupation is

the manufacture of garlands, chaplets, frontals, tiaras and crowns of very thin copper, on which purple, dark and light blue feathers of gorgeous brilliancy are laid with exquisite taste and skill. From the size of these ornaments great scope is afforded for the display of various figures. Sometimes two dragons extend from below the lobes of the ears, meeting above the forehead, the variegated scales of which are represented by minute portions of feathers of various hues; at others, beautiful flowers are interspersed with elegant mosaic, and then again the head attire appears animated, as with every turn of the fair one, tiny genii, birds, and insects are set in motion from springs and wires which retain them in the midst of the fairy-like garland. A more tasteful, elegant, or gorgeous blending of art and nature than is exhibited in one of these head dresses, perhaps no ingenuity has hitherto devised. To increase the effect, these ornaments are studded with pearls, produced cheaply and in great abundance by artificial means in a fresh water muscle. Commoner articles, such as earrings, and brooches for caps, are generally made of a small wreath of the forget-me-not, encircling one of these pearls. Half a dollar will purchase one of these when of silver, and a few cents the copper ones. The most expensive head dresses cost less than five dollars, unless of silver.

As this elegant art has not hitherto attracted the attention of foreigners, the mode of procedure should be described; this may be done in few words.

On the table at which the workman sits, he has a fasciculus of feathers, a small furnace with a few embers for keeping warm a cup of glue, a small cutting instrument like a screw-driver, a pencil or brush, and the articles, either silver, gilt, copper tinsel, or pasteboard which are to be feathered. The thumb and index finger being smeared with glue, the feathers are gently drawn between them, which stiffens the barbs, causing them to adhere firmly together; and when dry the perpendicular blade is drawn close to the shaft dividing it from the barbed portion. Holding this cutting implement as in writing *à la Chinoise*, the artist by pressing on the strips of barb with the knife, cuts them into the desired size and shape, which is a work of some delicacy—the pieces being very small, in the form of petals, scales, diamonds, squares, and the like, and requiring to be of the same size as the particular spot on which they are to be laid. Besides fingering this tool in the manner described, he holds the pencil nearly as we do a pen, dips it into the glue, brushes the spot to be coated, then expertly reversing it, touches with its opposite point a tiny bit of feather, which is thus lifted up and laid on the part for which it was fitted. Care is requisite also in giving a proper direction to this twilled work, for such of course is the appearance presented by the barbs.

The feathers most in demand for this purpose are from a beautiful species of *Alcedo*, brought from the tropical regions of Asia; they are employed for silver articles. King-fishers of coarser plumage, and less brilliant hue, found throughout the country, are used for ornaments made of copper or pasteboard. Blue always greatly predominates over lighter or darker shades, relieved by purple, white or yellow.

Whether Aztec silversmiths, whose ingenuity is so much lauded by the old Spanish chroniclers, practised this branch of plumagery or not is uncertain. There is reason to believe that what is said of their imitation of animals with moveable wings or limbs, of their representing scales of fish alternately of gold and silver, were nothing more than what is now done by the same craft in China; and which were esteemed very marvellous by Sir J. Mandeville (Voiage and Travaile), motion being communicated by wires and springs, and colors imparted by the plumage of choice birds. The construction of automata proper requires a knowledge of horological mechanism, never attained by either Chinese or Aztecs. Plumagery doubtless attained a far higher degree of excellence in Central America than in China, owing to the greater variety and extreme abundance of the feathered tribe in the dense and luxuriant forests of Mexico. Yet it is not likely that feather fabrics were so easily manufactured as to be worn by other than the nobles and affluent, to whom in China their use was confined. Had the Chinese been as destitute of textile fabrics as the Aztecs, they would unquestionably have engaged in plumagery with greater success.

ART. VIII.—*Binocular Microscope;* by Dr. E. D. NORTH.

COMMON stereoscopy is a full perception of the solid forms of objects by a peculiar mode of viewing their geometric projections on a flat surface. Flat pictures are thus made to represent objects with a relief as perfect as that of the objects themselves, and, what is more than relief, give us the perception of *looking around and almost behind* each cylindrical or spheroidal form. Not only is a bust or statue thus seen, but several figures in a group stand forward at different distances from each other, while the clear space between is fully perceived and affords an especial gratification. In strict imitation of ordinary vision with both eyes, two drawings or photographs at the same distance are seen and are united by the brain, as if both eyes were looking at a single solid object without the intervention of an optical instrument. The success of the stereoscope may be pronounced perfect; the view by means of two drawings affords the same amount

of knowledge, and with as much accuracy and satisfaction as a view of a real object with both eyes.

At first thought it seems strange that the stereoscope was not sooner invented. A full detail of the reasons why in the progress of the human mind this invention is so late, and how it is that we are able to do without it, would open up a wide field of interesting considerations, and include the philosophical and aesthetical principles of the art of painting.* It will be sufficient to hint at these uses of vision by which the eye is the mind's instrument for mathematical or strictly scientific perception and knowledge. Such knowledge depends on *measurement;* solids are analyzed and measured by means of planes; the third dimension is in a plane at right angles to that of the length and breadth; it is length or breadth in another direction. In judging of length or breadth by the eye, we measure by a process of halving and repeated bisection, and make the eye a mathematical instrument; but in the case of an actual solid whose position we can change, if we would obtain the same accuracy of knowledge in regard to the third dimension, we must *turn the object over* until depth becomes length or breadth. If the object cannot be turned over, the dimension which, as it lies, is that of depth, cannot be measured accurately by the eye, and cannot, so to speak, be mathematically perceived; hence stereoscopic vision, either when it is natural, as being the simultaneous act of both eyes or as that obtained by successive focal changes of a single eye, or when it is effected by suitable optical instruments, cannot be what we call mathematical vision or that which is attended with measurement.

But optical instruments are useful not only for their assistance in measurement or strict science, but also as adjuvants of perception, and in obtaining an endless amount of less definite knowledge which is needed in the mixed sciences. Facility, rapidity, satisfaction and pleasure are also important considerations. This is especially true of the microscope, an instrument as essentially necessary and indispensable in science as the telescope, and equally accurate and reliable with it in all its revelations.

Inexperienced persons are embarrassed, when judging of objects under the microscope, by their appearing as flat pictures; by an inability to perceive depth, and by the care and slowness with which the mind must be employed when the focus is

* When the utmost possible minuteness and accuracy of discrimination is needed by a watch-maker, engraver, by any extremely accurate mechanic, or by a naturalist or other scientific man, but one eye is employed. Spectacles which are lenses of low power for both eyes, are used solely because an individual's eyes do not see at certain average distances as well as mankind's in general—never strictly speaking for magnifying an object too small for good eyes. First the closest inspection by a single eye is employed and at the shortest working distance of the eye; if the object be still too minute, a single hand lens, and never a pair of them, are resorted to. Attempts have been made to introduce watchmaker's magnifiers in spectacle frames; yet they have not come into use.

adapted to different planes; while in the common stereoscope the impression of a solid object is, as we have before said, absolutely perfect; so that when an object is deeper than it is long or broad it will infallibly appear so, and we are enabled even to measure the depth, to a certain extent, by comparing it with the length or breadth as a unit.

Professor Riddell has practically succeeded in adding to the previous powers of the microscope all those of the other instrument now so common and popular; and with this great superiority, that whereas the latter can exhibit only pictures and those of large objects, being thus dependent on the accuracy of the drawing, or the success of the photograph, his binocular microscope exhibits minute objects themselves with perfect accuracy and truth as they exist in nature; presenting them as solids in which the dimension of depth or thickness and their distance in superposition, is of as much importance to truth of perception as that of length or breadth. Fortunate in being able to commit his plans to a truly scientific and accurate workman, one to be depended on for resource and avoidance of error in the minute details necessary for applying a general idea, he has received from Mr. Grunow an instrument of great beauty of workmanship and convenience, the performance of which is most satisfactory in reference to the objects aimed at.

For a full description of the optical arrangement by which binocular vision is attained, we refer the reader to Prof. Riddell's article on the "Binocular Microscope," read before the American Association for the Advancement of Science, July, 1853, and published in No. 5, of the Quarterly Journal of Microscopical Science.

As far as we have been able to observe, this arrangement is not liable, in any degree, to the charge of pseudoscopy, nor is any perceptible chromatic or spheroidal aberration produced by the interposition of prisms, which is sufficiently proved by the examination of minute mercury-globules.

The mechanical arrangement is excellent. The instrument is mounted on a solid, and very steady tripod stand of cast-iron, with a plain stage 4×6 inches. The focussing is performed by a carefully wrought rack and pinion movement with two large milled heads.

The necessary movements for adapting the distance of the eye-lenses to any pair of eyes and for adjusting the prisms, so as to cause the rays from the objective, after being divided, to emerge coincident with the axes of the two compound bodies, are also performed by rack and pinion, and are so arranged that they act equally and at the same time on both the right and left side. The image is inverted in one direction, and two small rect. prisms placed above the eye-pieces, make it appear in its natural position and thus adapt the instrument for dissecting.

As the Professor possesses several higher objectives, by Mr. Spencer, he has had executed by Mr. Grunow, at the same time with the Binocular, only an object-glass of 1 inch focus with which alone we have had an opportunity of trying the performance.

This object-glass has a large angle and is corrected exquisitely for chromatic and spherical aberration. That difficult point in microscopy, a view into deep cavities, is perfectly attained. The eye of a fine needle by incident light, exhibited the walls of a cavity deeper than broad; an opened anther cell preserved in fluid and happening to lie edgewise, exhibited by transmitted light its walls with clear vision to the bottom of the depth; the fibres of the fringed end of a silk ribbon floated in space in different planes of superposition with an enlargement of distance in the perpendicular direction strikingly correspondent to their horizontal separation. No doubling or thickening of lines, mistiness, fog or uncertainty accompanied the views, but vision was brilliant and clear, while thus looking into space instead of being as it were confined by an optical wall of limitation, to a single plane. Neither while thus looking far into space by magnifying distance in proportion to surface, was any thing lost in power of minute discrimination of lines and edges; these were sharply and clearly defined: in short true shape and form were perceived in their actual proportions instead of being flattened, and an entire whole seen, as Schacht expresses it, "in optical sections;" and were exhibited simultaneously with minuteness of detail on surfaces.

Thus may we congratulate ourselves that binocular vision, so long a desideratum in microscopical science, is at length attained; constituting, as it does, the first important step since the solution of the great problem of the achromatising of the microscope, and the power of enormously enlarging the aperture of the objective.

New Haven, March, 1854.

ART. IX.—*Mechanical Action of Heat;* by W. J. MACQUORN RANKINE.

Gentlemen—I beg leave to address to you the following remarks on a formula referred to in the very able and interesting paper of Professor Frederick A. P. Barnard on "Heated Air considered as a Motive Power," published in the American Journal of Science for March.

The formula in question represents the maximum efficiency of a perfect Thermo-dynamic Engine: that is to say, the greatest fractional portion of the total heat consumed which such an engine converts into motive power; and, in Prof. Barnard's notation, it is as follows:

Let H represent the mechanical equivalent of total heat expended;
W, the motive power developed;
τ'', the absolute temperature at which heat is received by the elastic substance which works the engine;
$\tau_,$ the absolute temperature at which heat is given out;
Then the efficiency of the engine is

$$\frac{W}{H}=\frac{\tau''-\tau_,}{\tau''} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (A.)$$

This formula is ascribed by Professor Barnard to Professor William Thomson of Glasgow.

The formula originally proposed by Professor Thomson is, however somewhat different in form from the above, being the following:

$$\frac{W}{H}=1-\varepsilon^{-\frac{1}{J}\int_{\tau_,}^{\tau''}\mu\, d\tau}; \quad . \quad . \quad . \quad . \quad . \quad (B.)$$

where ε is the base of Napier's logarithms; J, "Joule's Equivalent" = 1390 foot-pounds per centigrade degree in liquid water; and μ, "Carnôt's Function;" being an unknown function of temperature only, which has to be determined by experiment.

This formula was deduced by Professor Thomson from a combination of Carnôt's principle, *that the efficiency of a perfect thermodynamic engine is a function solely of the temperatures at which it receives and emits heat*, with the law established experimentally by Joule, of the convertibility of the different forms of physical energy. It appeared in a paper on the Dynamical Theory of Heat, read to the Royal Society of Edinburgh in 1851, published in the 20th volume of their Transactions, and reprinted in the London, Edinburgh and Dublin Philosophical Magazine for 1852, Series 4th, volume 4th.

During the same session of the Royal Society of Edinburgh, there was read the Fifth Section of my paper on the Mechanical Action of Heat, in which, from the hypothesis that heat consists in certain molecular oscillations or revolutions, I deduced the law, *that the efficiency of a perfect thermodynamic engine is expressed by the difference between the absolute temperatures at which it receives and emits heat, divided by the greater of those absolute temperatures diminished by a constant which is the same for all substances;* that is to say,

$$\frac{W}{H}=\frac{\tau''-\tau_,}{\tau''-\varkappa} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (C.)$$

The constant $\varkappa$, if not absolutely inappreciable, is so small that no material error in practice can arise from neglecting it in com-

puting the efficiency of engines. This reduces the formula C to identity with A.

The section to which I have referred was published in the 20th volume of the Transactions of the Royal Society of Edinburgh, and re-printed in the London, Edinburgh and Dublin Philosophical Magazine for March, 1854.

Professor Thomson afterwards pointed out, (in consequence of a suggestion by Mr. Joule) that if Carnôt's Function be supposed to have the following value

$$\mu = \frac{J}{t} \quad . \quad . \quad . \quad . \quad . \quad \text{(D.)}$$

the formula B is transformed into A.

It is also obvious, that if Carnôt's Function have the value

$$\mu = \frac{J}{t - \varkappa} \quad . \quad . \quad . \quad . \quad \text{(E.)}$$

B becomes identical with C.

Although the law expressed by the equation C, being partly founded on hypothetical principles, was at first to a certain extent conjectural, yet it has subsequently being so closely confirmed by the experiments of Messrs. Regnault, Joule, and Thomson, that it may be regarded as almost, if not altogether, demonstrated. It is still, however, uncertain, whether the constant $\varkappa$ has an appreciable value. The values computed from the experiments range from 0° to 2°·1 Centigrade; absolute temperatures being reckoned from a point 274°·6 Centigrade below melting ice, or 494°·28 below zero on Fahrenheit's scale. The constant $\varkappa$ represents the position, on the scale of a perfect-gas thermometer, of the point of total privation of heat. If the elasticity of a perfect gas arises wholly from heat, then this point coincides with the absolute zero of a perfect gas thermometer, and $\varkappa = 0$.

It gives me much gratification to find, that the conclusion to which Mr. Joule, Professor Thomson, and myself have been led by our researches, as to the great economy of fuel to be expected from the Air-Engine when its practical difficulties have been overcome, is confirmed by the opinion of an investigator who has so carefully examined the subject as Professor Barnard.

59 St. Vincent street, Glasgow, 14th April, 1854.

ART. X.—*On the Resistance experienced by Bodies falling through the Atmosphere;* by ELIAS LOOMIS, Professor of Mathematics and Natural Philosophy in New York University.

AT the Cleveland meeting of the American Association, I presented a paper on the hail storm of July 1st, 1853, and introduced some computations for the purpose of determining the velocity which hail stones acquire in falling through the atmosphere. These results were based upon the experiments of Hutton respecting the air's resistance to bodies in motion, as determined by a whirling machine. Since the case of a body revolving about a fixed axis is different from that of a body descending freely through the atmosphere under the action of gravity, I have endeavored to test these results by experiments upon the direct fall of bodies. For this purpose I have performed various experiments upon the velocity acquired by falling drops of water; also by small spheres made of cork; and have experimented with lumps of ice varying from the size of a pigeon's egg up to masses weighing more than two pounds. These results coincided tolerably well with those obtained by computation from Hutton's data, but I refrain from publishing them at present in the hope of being able to repeat them with greater care and with the advantage of a greater elevation.

In the mean time I have sought for experiments of a similar kind made by other individuals. The experiments made at the request of Newton in St. Paul's Cathedral at London, seemed better suited to my purpose than any others I have found. There were two series of these experiments. In the first series, made in the year 1710, several hollow glass globes of about five inches in diameter were let fall from an elevation of 220 English feet, and the times of descent carefully measured. In the second series of experiments made in the year 1719, several bladders formed into spheres about five inches in diameter, were let fall from a height of 272 feet, and the times of descent carefully observed.

For the purpose of deducing from these experiments the coefficient of resistance, I proceeded in the following manner. It is evident that the resistance to a falling body beginning from zero, continually increases with the increasing velocity of the body; and since the impelling force is constantly the same, while the resisting force always increases, it must happen that the latter will at length become equal to the former. When this result takes place, that is, when the resistance is just equal to the weight of the body, there can be no further increase of velocity, and the body must thenceforth descend with a uniform motion. I found that in the first series of Newton's experiments, the velocity of

descent became sensibly uniform after a fall of 40 feet; and in the second series of experiments after a fall of 10 feet. I carefully computed the time of descent through the space just mentioned, and dividing the remaining distance by the remaining time of descent, obtained the terminal velocity, from which the coefficient of resistance is easily deduced.

In these computations I made use of Hutton's formulæ which are as follows:

$$\frac{4gcx}{w} = \text{h. log. } \frac{w}{w - cv^2} = \text{h. log. N.}$$

$$v = \sqrt{\frac{N-1}{Nc}} \cdot w$$

$$t = \frac{1}{4g}\sqrt{\frac{w}{c}} \times \text{h. log. } \frac{\sqrt{\frac{w}{c}} + v}{\sqrt{\frac{w}{c}} - v.}$$

$$c = \frac{w}{v'^2}$$

Where

c = the coefficient of resistance,
$g = 16\frac{1}{12}$ feet,
w = the weight of the body expressed in ounces,
x = the space fallen through,
v = the velocity acquired in falling through the space x,
t = the time of descent through the space x,
v' = the terminal velocity of the body.

The following Table shows the results deduced from the first series of experiments with glass globes. Column first shows the weight of the globes in grains; column second shows their diameters in inches; column third shows the entire time of falling from a height of 220 feet; column fourth shows the velocity acquired in falling through a space of 40 feet; column fifth shows the time of falling 40 feet; column sixth shows the coefficient of resistance deduced from the time of descent; and column seventh shows the same coefficient reduced to a sphere of 5 inches in diameter by assuming the resistance to vary as the square of the diameter.

Weights of the globes.	Diamet'rs of the globes.	Whole times of falling.	Velocity in falling 40 ft.	Time of falling 40 feet.	Coefficient of resistance.	Do. reduced to a sphere of 5 in.
grains.	inches.	s.		s.		
510	5·1	8·2	28·237	1·9967	·0013845	·0013307
642	5·2	7·7	30·026	1·9386	·0015033	·0013899
599	5·1	7·7	30·070	1·9373	·0014033	·0013488
515	5·	7·95	29·183	1·9650	·0013014	·0013014
483	5·	8·2	28·383	1·9917	·0013133	·0013133
641	5·2	7·9	30·099	1·9364	·0015022	·0013888

In making these computations I was obliged to assume a probable value of c for the purpose of computing v and t; but the value of c deduced from the formula $c = \frac{w}{v^{1\cdot2}}$ is but slightly affected by an error in the first assumed value of c. In order however to eliminate even this small influence, having computed the value of c by these formulæ, I repeated the computation for v and t with the value of c thus deduced, by which means I obtained a second determination of c which is almost wholly independent of the first assumed value.

The mean of the preceding values of c for a sphere of 5 inches in diameter is ·0013455; whence for a velocity of 30 feet, which is about the terminal velocity in the preceding experiments, the resistance on a sphere 5 inches in diameter is 1·2109 ounces.

The following Table shows the results deduced from the second series of experiments with bladders, arranged as in the former table. The entire space fallen through was 272 feet. Columns four and five were computed for a descent of 10 feet.

Weights of the bladders.	Diameters of the bladders	Whole times of falling.	Velocity in falling 10 ft.	Time of falling 10 feet.	Coefficient of resistance.	Do. reduced to a sphere of 5 in.
grains.	inches.	s.		s.		
128	5·28	19	14·200	0·9955	·0013816	·0012390
156	5·19	17	15·581	0·9528	·0013376	·0012415
137·5	5·3	18·5	14·539	0·9844	·0014047	·0012501
97·5	5·26	22	12·375	1·0690	·0014223	·0012852
99·125	5·	21·125	12·911	1·0450	·0013308	·0013308

The mean of the preceding values of c for a sphere of 5 inches in diameter is ·0012693, whence for a velocity of 15 feet, which is about the terminal velocity in the preceding experiments, the resistance on a sphere 5 inches in diameter is ·2856 ounces.

In the year 1802, a great number of experiments on falling bodies were made by Benzenberg in the tower of St. Michael's church at Hamburg. Metallic balls about one and a half inches in diameter were allowed to fall from heights varying from 25 to 340 French feet, and the times of descent were measured by a watch having a hand which made one revolution per second. These experiments were performed with the greatest care; but since the specific gravity of the balls employed was more than ten times that of water, they do not appear to me as well adapted to indicate the amount of resistance, especially for small velocities, as the experiments of Newton.

Newton's experiments have furnished us the resistance on a sphere 5 inches in diameter, at the two velocities of 15 and 30 feet per second. We will now compare these results with those obtained by Hutton with the whirling machine. Hutton determined the resistance upon a sphere of pasteboard $6\frac{3}{8}$ inches in diameter, for velocities from 3 to 20 feet per second. I have reduced these results to a sphere 5 inches in diameter by assuming

the resistance on spheres to vary as the squares of their diameters. I have also added the resistance to a velocity of 30 feet per second, computed upon the assumption that the resistance varies as the square of the velocity.

In the following Table, column first shows the velocity in feet per second; column second shows the resistance to a sphere 5 inches in diameter, moving with velocities expressed in the first column, deduced from Hutton's experiments with the whirling machine; column third exhibits the same numbers corrected so as to conform to the results of Newton's experiments.

Velocity per second.	Resistance from Hutton's experiments.	Do. from Newton's experiments.	Velocity per second	Resistance from Hutton's experiments.	Do. from Newton's experiments.	Velocity per second.	Resistance from Hutton's experiments.	Do. from Newton's experiments.	Velocity per second.	Resistance from Hutton's experiments.	Do. from Newton's experiments.
feet.	ounces.	ounces.	feet.	ounces.	ounces.	feet.	ounces.	ounces.	feet.	ounces.	ounces.
3	·017	·014	8	·100	·080	13	·268	·214	18	·522	·417
4	·029	·023	9	·127	·102	14	·311	·249	19	·584	·467
5	·042	·034	10	·157	·126	15	·357	·286	20	·650	·520
6	·058	·047	11	·191	·153	16	·408	·326	30	1·487	1·211
7	·077	·062	12	·228	·182	17	·463	·370			

The resistances deduced from Newton's experiments at velocities of 15 and 30 feet per second are about one-fifth less than those obtained by Hutton. Diminishing the numbers in column second by one fifth part we obtain the numbers in column third which are presumed to represent the resistance in conformity with Newton's experiments.

If now we assume the specific gravity of ice to be 0·865 as given in the French Annuaire, the weight of spheres of ice 2, 1 and ½ inches in diameter will be as follows; and the greatest velocities which they can acquire by falling through the atmosphere are shown in the following Table.

Diameter of sphere.	Weight of sphere.	Terminal velocity.
2 inches.	2·0908 ounces.	98 feet.
1 "	0·2614 "	70 "
½ "	0·0327 "	49 "

Art. XI.—*The Brandon Tornado of January 20th*, 1854; by O. N. Stoddard, Prof. Chem. and Nat. Phil., Miami University, Ohio.

The whole breadth of the State of Ohio from Southwest to Northeast, was swept on the 20th of January, 1854, by a storm of unusual violence.

Traces of the same storm have been obtained from a point 27 miles N. E. of Little Rock, Arkansas, also from the western part of Pennsylvania. The whole length cannot be less than 800

miles. The breadth, I have not been able to determine. At Dubuque, Iowa, on the 20th of January, it was clear and very cold, with the wind from the N. W. At the point named in Arkansas, heavy rains from the southwest occurred on the 19th, followed by a clear and cold atmosphere on the morning of the 20th. On this day, the 20th, the storm passed over Ohio.

The temperature became mild on the 19th, and on the next day at noon, the thermometer stood at 70° in Cincinnati, and 68° in Oxford; the latter place more elevated than Cincinnati and about 30 miles from it, N. by W. The barometer fell gradually during the 19th, and rapidly on the 20th; and at 45 minutes past 12 M. the time when the storm began at Oxford, it stood 28·21; lower than at any period during the last twelve months. The air was saturated with vapor, and the walls of brick buildings were dripping with moisture. Three strata of clouds were distinctly observed: the highest cirri light and fleecy, moving towards the N. E.; the second, the proper storm-cloud in dark heavy masses, moving rapidly in the same direction; the third and lowest, the scud of sailors, flitting violently past, a little east of North. Along the track of this wind, there were at different times during the day, violent rains, vivid lightning, heavy thunder; and in some places large hailstones fell, though not in great quantity. In the northeastern part of the state the storm assumed the form of a tornado of great violence.

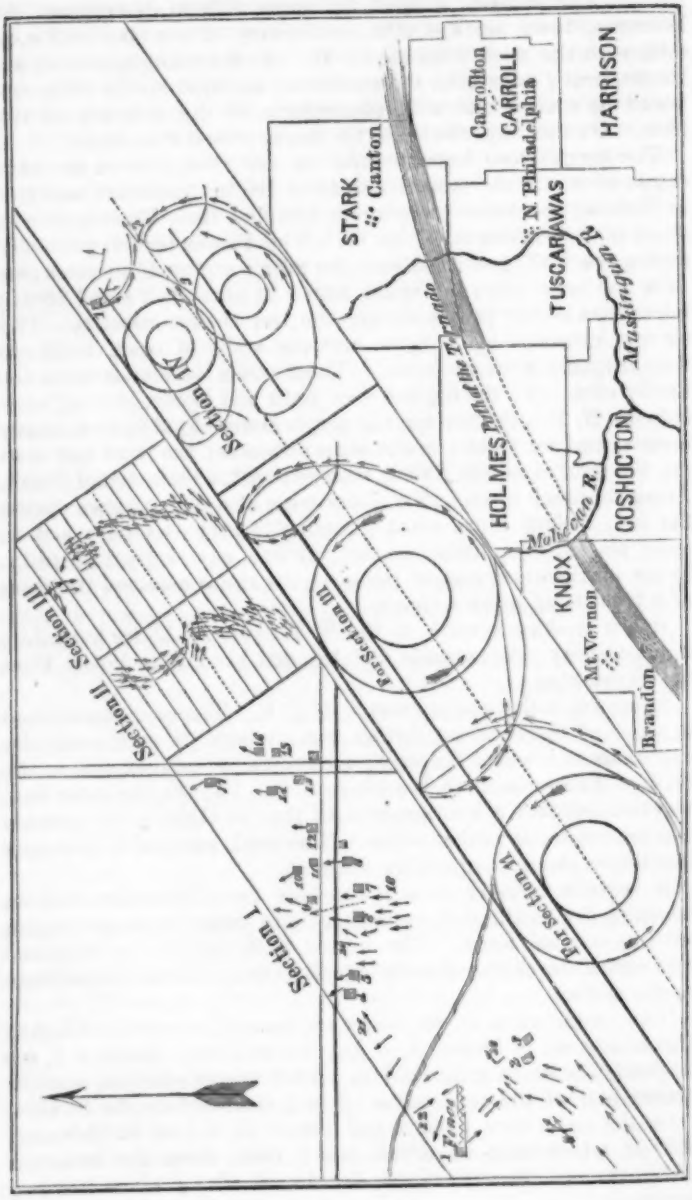
It first struck the earth in the S. W. part of Miller township, Knox County; N. Latitude 40° 18′, and Longitude 5° 30′ West of Washington.

Its course in that county was N. 56¼° E. Traces of it are found in some of the counties farther east; where its path gradually curved more towards the east; presenting its convex side to the north. The tornado in Washington Co. Pa., on the same day, was not probably a continuation of that in Ohio, as its location was several miles farther south. The track pursued in this state is given in the accompanying diagram.

It appears to have passed over one tier of counties without touching the earth, and subsequently to have descended again with its original force. The dotted lines exhibit its supposed path above the earth; the shaded part, the localities of its ravages on the surface.

The examination by the writer commenced one and one-fourth mile southwest of Brandon, at Dr. Baxter's barn, (marked 1, see diagram) the north gable end of which was crushed in, and the eastern half of the roof taken off and scattered to the S. East.

On the right were a barn and house (2, 3,) of E. Coleman, both of which were unroofed, and a rafter from the barn was driven through the side of the house and into a chest standing within.


STARK
Canton
Carrollton
CARROLL
N. Philadelphia
HARRISON
TUSCARAWAS
Muskingum R.
HOLMES
Path of the Tornado
COSHOCTON
Mohecan R.
KNOX
Mt. Vernon
Brandon
Section IV
Section III
Section II
Section I
Fort Section III
Fort Section II
Fort Section I

The tornado then crossed the valley of Sycamore creek, and ascending a gentle slope on the eastern side, struck Dr. Wheaton's house and barn, (4, 5,) which were utterly demolished. A brick church (6), a brick school-house (7), and a log house (8), were entirely swept from their foundations. A Presbyterian Church (9) was unroofed; a small frame house (11) had the roof and ceiling raised but not thrown off; an out-house (10) was destroyed; a stable (12) was also unroofed; a large frame house (13) was moved 18 inches from its foundations; a stable (14) carried 12 feet; a blacksmith and wagon shop (15, 16) and E. Squire's brick house (17) were prostrated. Some small buildings on the right, not represented, were unroofed or otherwise injured. About one-fourth of a mile east of Brandon it struck a dense forest. At this point a careful survey was made across the track; represented by Section II. For nearly three miles its course was mainly through the forest, with intervals of cleared land, uprooting or breaking almost every tree, and crushing the buildings which unfortunately stood in its way. Crossing the Newark and Mt. Vernon railroad, it swept over cultivated fields, destroying the few trees which had been left, and razing to the ground a stable and brick house. Three-fourths of a mile beyond this, an open grove of very large trees, mostly oak, stood on rising ground and in the line of the storm's axis. They seemed like an advanced guard to the forest a little farther in advance. The tornado struck them with appaling fury, and appeared well nigh irresistible. Scarcely one was left standing; some were uprooted, others broken, and split into fragments.

Near this place where it entered the forest, another survey was made (see Section III). In this survey, as well as the other explorations made during this day, the writer was aided by Rev. R. C. Colmery, of Mt. Vernon. A part of the forest here passed through was heavily timbered and covered with a dense undergrowth. Though the action of the wind was less symmetrical while struggling through and entangled among so many obstacles, yet the renewal of the velocity as fast as destroyed, and the force with which it plunged down and clung to the earth, were exceedingly interesting features of its workings.

Its path was followed several miles farther, in all about eleven miles, and occasional bearings taken, but as they corresponded entirely with the previous ones, no special record was made of them. The breadth of the track became somewhat less, but without any decrease in violence. Houses included in its vortex were still demolished; a horse was lifted into the air and carried over a fence; a cow was blown twelve rods against a tree, striking it twelve feet from the ground. In the vicinity of Gambier, after a course of twelve miles, its destructive influence was for a while suspended, till it again struck the earth in another county.

Having made these general statements, we may now examine more particularly the bearings of objects prostrated by the wind. The following table contains the bearings of a survey across the path of the tornado, 1¼ mile S. West of Brandon, commencing on the right. The plot of these bearings will be found in the left part of Section I.

	Course of the storm,	N. 56¼° E.	
1.	A tree, - - -	N. 56¼° E.	
2.	" - - -	N. 45° E.	
3.	" - - -	N. 56¼° E.	
4.	" - - -	N. 22½° E.	
5.	Several trees, -	N. 45° E.	
6.	A tree, - - -	N. 22° E.	
7.	" overlying 6,	N.	
8.	" - - -	N.	
9.	" across 8, -	N. 22° E.	
10.	" across 9, -	N. 56¼° E.	
11.	A fence, - -	N. 6° W.	This was near the middle of the track.
12.	A tree, - - -	N. 11¼° W.	
13.	A hickory, diagram (23)	N. 45° W.	The top after falling broken off and turned round to the East.
14.	Three oaks, - -	N. 45° E.	Near the hickory, but much smaller.
15.	Trees in orchard, -	E. 10° S.	
16.	Roof of Baxter's barn,	E. 45° S.	

A fence at this point, running east from Baxter's barn, was found to have been thrown along the western half towards the south, while the eastern half was prostrated northerly. This prostration of the halves of the fence in opposite directions, together with other peculiarities in the position of objects, induced the writer to believe that a secondary or double whirl existed at this place, the one on the right being in advance of the other.

The hickory was thrown down (Section 4, No. 2) across a ravine, and afterwards half of the tree, including the top, was turned round towards the east. The same current which produced this effect, prostrated three small oaks (3). The shingles from Baxter's barn (1) were first carried southeast, and then strewed for fifty rods in a curved line gradually bending in towards the course of the storm. The curved arrows from the barn correctly represent the arrangement of the shingles. Trees in an orchard near by were thrown down E. 10° S., coinciding in direction with the fragments from the barn.

The central whirl of the storm passing over the hickory and oaks, might account for their position, but not for that of the fence. The evidence from the latter of a secondary whirl, was as clear and explicit as well could be. Had the rails been removed by hand and laid on opposite sides, the result could not have been more regular. A secondary whirl about 60 rods in diameter, lagging a little behind the more extended one on the right, seems undeniable from the facts in the case.

To what extent this may have disturbed the general action, it is impossible to say. Its existence, if admitted, did not however

continue long, for all trace of it is lost in the forest one-fourth of a mile east of Brandon.

We will now examine briefly the action of the tornado at Brandon. The right hand part of this storm seems to have slid over that division of the town, merely prostrating fences and unroofing some small buildings. Its destructive effects were felt mainly in the middle and left hand portions.

A careful examination on the right of the path through the town, was not made; the approach of night cut it short: and the subsequent observations were given to a part of the track farther east. Section I represents that portion of the town most severely visited; and the arrows represent the direction in which objects were prostrated. The cluster of arrows (18) mark the position of trees in an orchard. Their direction was from N. to N. 10 W. Casting the eye from this point along the track of the storm, the buildings 7, 8, 12, 14, 15, 16, give the same general result. Combining them we obtain the mean N. 5° W. If we take another section farther to the left, commencing with the brick church (6) and extending nearly to Dr. Wheaton's house (5), we obtain a mean result of N. 15° 5′ W. From this estimate a tree (20) and the church (9) are rejected. No. 20 was an apple tree which had been twisted more than 45° after falling. The roof of the church was torn to fragments and scattered between N. E. and N. W. The direction in which the wind struck the church, can be made out with sufficient accuracy from other data. 1st, The south gable end was crushed in, and 2d, A bier was lifted from the grave yard, carried across the street along the line of the dotted arrow, and set down in the church yard.

The remaining objects on the left including Dr. Wheaton's house and barn, and the trees near the creek give a bearing of N. 33° 45′ W. From this 21 was rejected. It was a small oak, broken partly off, and turned round 90°. No. 22 was a limb from a tree carried S. 10° E.; supposed to be due to the reverse action of the storm. In the tabular view of these bearings given below, in order to fill it out for the right of the track, for which no materials existed in Brandon, the first three are interpolated from a survey farther west.

1.	N. 56¼° E.	5.	N. 15° 5′ W.
2.	N. 50° 37′ E.	6.	N. 33° 45′ W.
3.	N. 33° 45′ E.	7.	S. 10° E.
4.	N. 5° W.		

The bearings from this table are remarkable; and if the reader will construct a curve to suit them, he will find a singular correspondence with the cycloids which were planned with special reference to Sections II and III.

To these sections we will now turn. Section II represents a survey across the path of the storm, one-fourth mile east of Brandon, where it first struck the forest. The distances from bearing to bearing were not measured with a chain: it would have been impossible to use one in the midst of such a mass of fallen timber. They were determined, as nearly as could be, by the eye. On the right of the dotted line, the number of bearings might have been increased to any extent, as the ground was covered with fallen trees. The largest and straightest trees were selected. Those which were partially decayed or which had been thrown down by others were rejected. The arrows do not in every instance represent the relative distances of the trees from each other; in many cases they lie side by side in contact. On the left of the dotted line, they are sometimes placed nearer in the plot than was actually their position. The direction is accurately given. The arrows with cross-bars point out trees which lay across others. The prostrations appear to have been made almost entirely by the front of the tornado, with the exception of the left hand portion of the path, where the reverse action was frequently the most violent. This front action rendered the position of the trees more symmetrical, and the mode of action of the wind easier of solution. Objects thrown down at the first stroke of the current would accurately represent a tangent to the curve at that point, whatever the nature of the curve might be. As the trees which fell above others, must have been struck down after a part of the storm had passed, and cannot therefore exhibit the front action, they are on this account either rejected in obtaining the mean of the bearings, or included with others in the reverse action. The parallel lines were drawn to aid the eye in grouping the trees. Where the trees lie across them, they are included in that interval whose bearings most nearly correspond.

A tabular view of Section II, one-fourth mile east of Brandon,—¼ mile wide.

Course of the storm,		N. 56½° E.
1	group,	N. 45° E.
2	"	N. 34° E.
3	"	N. 8° 53′ E.
4	"	N. 10° 7′ W.
5	"	N. 23° W.
6	"	E.
7	"	E. 84° S.
8	"	E. 45° S.
9	"	E. 78° S.
10	"	E. 67° S.
11	"	S.

A tabular view of Section III, six miles east of Brandon,—¼ mile wide.

1	group,	N. 56° 15′ E.
2	"	N. 29° 24′ E.
3	"	N. 11° 15′ E.
4	"	N. 6° E.
5	"	N. 10° W.
6	"	N. 22° W.
7	"	N. 33° 45′ W.
8	"	N. 78° W.
9	"	W.
10	"	W. 45° S.
11	"	S.
12	"	S. 22° E.
13	"	S. 33° E.
14	"	S. 45° E.

The curtate cycloids were constructed to represent approximately these tabular views. The radius of the generating circle is to that which describes the curve as 1 : 2. The blanks in the

loop of either section could be supplied by interpolation from the other.

The barred arrows on the left of the loop in Section III designate trees which, though lying side by side with those on the opposite part of the same loop, yet rested with their limbs above the latter. The barred arrow in Section II which lies at the intersection of the curve was resting upon six large trees. An involute converging rapidly towards the centre might answer tolerably well the conditions of Section II, but it fails entirely when applied to Section III.

The involute action does not seem to have been distinctly marked. While passing rapidly over another part of the track, the bearings of scattering trees which were taken afforded more significant indications of the involute form near the axis. The relative distances in the latter case were not noted with sufficient accuracy to justify a projection.

The data thus far given are believed to be sufficient to enable the reader to form an intelligent opinion of the mode of action of this tornado. A few additional observations may afford some further aid.

1st. The space between the dotted line and the right hand border of the storm includes the path of most destructive violence. Within this limit almost every tree was prostrated or broken. This limit was clearly defined, especially on the left where the tornado first encountered the forest; but after plunging into it for some distance, its action became more obscure, and less symmetrical.

2d. On the left of the dotted line the force was much less violent, but trees enough were prostrated to determine the direction of the wind.

3d. No case was found of an object on the right thrown inward more than 11° or 12°. The mass of the trees on the right border lay parallel with the course of the storm.

4th. Along the dotted line, the trees generally lay N. 23° W.; making an angle of 79¼° with the general course of the storm.

5. Very few cases were observed of objects in the centre thrown forward in the direction of the path.

6th. There was no distinct case of the outward explosive action in buildings. The ascending current was, notwithstanding, very violent, for large objects were raised and transported several miles.

7th. Persons just outside of the path describe the storm as a column of vapor or smoke, whirling in indescribable confusion, accompanied with a deafening roar, so that the thunder, if any, was undistinguishable amid the general din and confusion.

8th. The atmosphere on the borders of the track appeared to suffer but little disturbance from the passage of the storm; and no current could be observed setting in towards it.

9th. There was scarcely any hail, but torrents of rain followed the tornado, equally, and perhaps, more abundant outside of the track than within it.

10th. The temperature sunk so rapidly that the next and succeeding days became marked as among the coldest in the month.

Rate of Progress.

Great discrepancy existed between different ooservers in reference to the progress of the storm. The estimated time of its passage over any one place varied from one-half to one and a half minutes. Mr. Coleman stated that he saw the whirling mass coming when three-fourths of a mile distant, and that he took scarcely five steps before he was struck down. If we take one minute as the time of its passage over any point, and three-fourths of a mile as the diameter of the storm, we obtain a velocity of 45 miles per hour.

I have not been able to obtain the barometric minima along the track of this extended S. West current; but if the lowest depression of the atmospheric wave passed near Little Rock, Arkansas, at noon on the 19th, then to have reached Oxford, Ohio, at 12½ P. M. on the 20th, would have required a velocity of nearly 29 miles per hour. My own opinion is that the first estimate is nearer the truth. The clouds during the forenoon of the 20th, flew past with a velocity which attracted special attention.*

In reference to the velocity of rotation an approximate estimate only can be reached. If the ratio of the progressive and rotary velocities adopted in the construction of the cycloid be correct, and 40 miles per hour be taken as the rate of progress, then the velocity of the wind on the right would have been 120 miles per hour. This velocity would be increased, especially near the axis, by the involute form of the curve; but to what extent this operated cannot be stated.

Another mode of estimating the force of the wind may be adopted. Among the oaks previously named as standing on rising ground, was one, a giant among giants. Its trunk was three feet in diameter and straight; its top symmetrical, and the whole sound to the core. It was shivered to fragments near the ground.

* Since writing the above, a communication from Mr. Raiff of Sandyville, north-eastern part of Tuscarawas Co., states, that the tornado passed about 1 mile south of that place at *half past three* o'clock P. M.; moving in a direction north of east, but gradually curving towards the east. It commenced southwesterly about 2½ miles from Sandyville, and passed on to the east; in all a course of 17 miles. The direction corresponds with what has already been stated.

The roar of the tornado burst upon Brandon while the clock was striking 2 P. M. From this to Sandyville is 67 miles, which the storm swept over in an hour and a half; which gives a progressive velocity of 44⅔ miles per hour. This corresponds very closely with the previous estimate, the difference being only one-third of a mile. The mode of action seems to have been the same; parts of buildings, it is stated, were carried to the north, some to the southeast, and others to the west of the foundations.

Let us estimate the force necessary to break it. We will call the diameter 2½ feet, the height 80 feet, the outline of the top a rectangle 50 feet by 40; and let us suppose the whole surface exposed to the wind to equal one-fourth of that included in the outline, or 500 square feet. Under these conditions the resultant of all the forces would act on the tree at a distance of 55 feet from the point of fracture. Taking the strength of oak at the usual standard, a force of 73,636 lbs. would be required to break the tree. If the surface exposed to the action of the wind be estimated at 500 square feet, the pressure upon each square foot would be 147 lbs. This gives a velocity of 172·9 miles per hour, equal to 253·5 feet per second. This is about one-fourth the velocity of a cannon ball. Though the above estimate gives an enormous force to the wind, yet I cannot perceive that any of the assumptions are exaggerated. The most doubtful point is the amount of surface supposed to be presented to the wind by the limbs, &c. The estimate is believed to be a large one, as the trees were at the time destitute of foliage.

Other circumstances are not wanting to sustain this view of a high rate of velocity in the tornado. A mass of brick cemented together, 4 feet by 3 and 1 foot thick, containing at least 12 cubic feet, and weighing more than 1000 lbs., was carried 15 feet from the wall of a house. A board was driven 3 inches into a charred oak stump. The writer pulled a shingle from an oak tree which had been driven into it one inch. An estimate of the force, in the aggregate, of this tornado, if made clear to the mind, by comparison with some well known standard, would excite astonishment. If any one will take the trouble to make the calcution, he will probably assent to the following: a section of it one half mile wide and 100 feet high, exerted a force equal to half the steam power of the globe. More than 50,000 trees were prostrated or broken by it in less than one half hour.

It is not my purpose to speculate upon any cause or causes which could generate such an enormous force. Ohio has been remarkable for the number and violence of its tornados during the winter. It is important to state another fact in this connection. A southwest wind has prevailed to an unusual degree this winter, and the tornados have been found imbedded in and moving with the general current. The writer has no theory to present in regard to their causes, or their mode of action. In the present case he has adopted that curve which the data seemed to demand.

In conclusion, the writer would take this occasion to acknowledge his obligations to those gentlemen at Brandon and Mt. Vernon, who afforded every aid in their power; also to the superintendents of the Cincinnati and Columbus, and the H. and D. railroads, who generously tendered him a free ticket for more than 300 miles of travel.

ART. XII.—*Considerations on the Group of Small Planets situated between Mars and Jupiter;* by M. U.-J. LE VERRIER.*

WE cannot doubt that our solar system is far more complicated than has hitherto been supposed. To say nothing of the immense number of comets which apppear to belong to this system, or of the meteors whose path lies near the orbit of the earth, we can still find in the asteroids situated between Mars and Jupiter, the catalogue of which goes on increasing each day, a fruitful subject of reflection and research.

In regard to the small planets discovered at the beginning of the present century, Olbers threw out the idea, that they were derived from the ruins of one larger planet. This hypothesis, which was based upon no very precise data, and which is inconsistent with the great inclination of the orbit of Pallas, must be abandoned; especially since the numerous discoveries of the last few years. Instead of explaining the existence of these bodies by supposing an alteration in the primitive system of the universe, we are now led to believe rather, that they have been formed regularly, like the others, and according to the same laws.

If these views are just, we ought to expect the discovery of a very large number of small planets; in proportion to the zeal with which observers shall extend their researches and to the possibility of employing more powerful instruments. The liberality with which astronomers, who have been recently engaged in these examinations, have submitted to the public their facilities of discovery, in the publication of costly ecliptic charts, has rendered this labor henceforth easy. The multiplicity of discoveries in this field, instead of diminishing the interest in them, is of a nature rather to enhance their importance. For if it has been necessary to give up the hypothesis of Olbers, it may be hoped at least that the knowledge of a great number of small planets will lead to the discovery of some law in their distribution, and to the determination of the configuration of their principal groups. It is hardly credible that these asteroids should be scattered promiscuously in all parts of the heavens: besides their having been discovered hitherto only in a single zone, we must suppose that the same cause which has brought together so much matter in each of the principal planets, has distributed all the rest also into separate and distinct groups.

We are acquainted at present with the orbits of *twenty-six* asteroids (omitting in these remarks the twenty-seventh just discovered by Mr. Hind). These twenty-six asteroids having been found under diverse circumstances and by different observers, are as we believe capable of furnishing some grounds for generaliza-

* From the Comptes Rendus, vol. xxxvii, p. 793.

tion upon the whole group to which they belong. This is what we propose here to examine.

The small planets revolve in a zone which begins at the mean distance of 2·20 from the sun and extends to the distance of 3·16; unity being here the mean distance of the earth from the sun.

The excentricities of the orbits are quite considerable; their mean rising to 0·155. The amount of excentricity in each one seems to bear no relation to the mean distance from the sun, or to the longitude of the perihelion.

The inclinations of the orbits, both with reference to each other and to the ecliptic, are also quite large. The mean of the sines of the inclination to the ecliptic is 0·155. The amount of the inclination in each one does not appear to depend either upon the mean distance from the sun, or upon the direction of the ascending node.

The perihelia and the ascending nodes present some special peculiarities. The perihelia of *twenty* of them, having their longitudes between 4° and 184°, are embraced in an extent of the heavens less than a semi-circumference. The ascending nodes of the orbits of *twenty-two*, whose longitudes are between 36° and 216°, are also comprised within less than half of the circumference of the heavens, and nearly coincident with the space occupied by their perihelia. Possibly we may trace a regular difference between the mean direction of the ascending nodes of the planets nearest to the sun and of those more remote, and so have ground for the conjecture that these asteroids belong really to two distinct groups. But we pass this by for the present. What has been said suffices for our present purpose; viz., *the determination of a superior limit of the total mass of matter that can exist in the zone of the heavens which we are considering.*

Such an investigation can be based only upon a close examination of the nature and amount of the influences exerted by this matter upon the nearer planets, Mars and the Earth. The different terms into which we commonly resolve these influences are not equally well suited to our object. The periodic terms, depending upon the relative situation of the planets influenced and the small masses which act upon them, neutralize each other, if there are a great number of asteroids situated at each instant in every part of the heavens: so that the sum total of the disturbing masses may be very considerable and yet neither Mars nor the Earth suffer annual and sensible perturbations.

The secular variations of the elements of the orbits do not depend upon the relative positions of the bodies, and consequently are not subject to the inconvenience which I have pointed out. Those of the terms of secular variation, which depend upon the longitude of the perihelia and nodes, may however present analo-

gous difficulties, which we can eliminate only by considering the terms in which the longitude of these elements does not enter, if such terms exist. Now the motion of the perihelion, whether of Mars or the Earth, actually contains a sensible term of this kind: this term depends only upon the mean distance of the asteroids from the sun and upon the excentricity of the disturbed planet; moreover it is essentially positive whatever may be that of the small planets whose action upon Mars and the Earth we are here considering, so that all these small masses combine by their action to impress direct motions upon the perihelia of the two principal planets here referred to. If then we suppose that the zone in which these small planets are found contains a very great number of others like them, we should conclude that the whole group acts upon the perihelia very nearly as if they were collected into a single mass situated at a proper mean distance, and we should deduce therefrom the means of determining the total mass, or at least a limit which it cannot exceed.

This subject however presents other difficulties. Besides the term upon which we have been reasoning there is a second in the expression of the motion of the perihelion, of the same mathematical order of magnitude as the first, but which depends upon the direction of the perihelia of the several disturbing masses: it is important to inquire whether it can modify the results furnished by the first term.

If the perihelia of the asteroids, known and unknown, were distributed uniformly in all parts of the zodiac, the second term of the motion of the perihelion of Mars or of the Earth might be neglected; because the action of those masses, whose perihelia are situated in one half of the heavens, would be destroyed in this second term by the action of those masses whose perihelia are in the other half. But we have seen that there is great liability to error in reckoning upon such a uniformity in their distribution; the perihelia of twenty out of twenty-six being placed in one-half of the heavens, a result doubtless not of chance and seeming to indicate that the matter whose mass we are investigating is nearer the sun on the side of the summer solstice than of the winter. This circumstance must be taken into consideration, not for the purpose of introducing it as an essential condition into the solution of the problem, but on the contrary of arriving at a result which shall be independent of it.

This consideration will lead us not to make use of the motion of the earth's perihelion although it is better known than that of Mars. The earth's perihelion being in fact situated in that very portion of the heavens occupied by the perihelia of more than three-fourths of the asteroids, the second term which enters into the expression of its motion may become appreciable as compared with the first and of the contrary sign: inasmuch as these

terms are respectively proportional to the excentricities of the terrestrial orbit and the orbits of the small planets, and as the excentricities of these last are at the mean nine times greater than that of the earth.

The perihelion of Mars is situated much more favorably in relation to the mean direction of the perihelia of the asteroids; and besides the excentricity of its orbit is greater. As a result of these two conditions united, the second term which enters into the expression of the motion of the perihelion is only one *fourth* of the first. Now this superiority of the first term may be expected to continue after the discovery of a great number of new asteroids, whether this predominance of the perihelia in the mean direction of the summer solstice shall be confirmed, as it probably will be, or whether we shall be obliged to return to the idea of a uniform distribution of them through every part of the heavens.

In accordance with these remarks I have found that if the mass of the whole group of asteroids was equal to the mass of the earth, it would produce in the heliocentric longitude of the perihelion of Mars an inequality which in a century will amount to eleven seconds. Such an inequality, supposing it to exist, surely could not have escaped the notice of astronomers. If we reflect that this inequality will become strikingly sensible at the moment of the opposition of Mars, we must believe that at present and although the orbit of Mars has not been determined with perfect accuracy it cannot nevertheless admit of an error in longitude greater than one-fourth of the inequality which we have pointed out. Hence we conclude that *the sum total of the matter constituting the small planets situated between the mean distances* 2·20 *and* 3·16 *cannot exceed about one-fourth of the mass of the Earth.*

Similar conclusions may be reached by considering the motion of the plane of the ecliptic; the result will depend however in that case upon the hypothesis that the ascending nodes of more than three-fourths of the orbits are situated in a semi-circumference. The limit moreover which we should reach in this way would not be so narrow. We stop then for the present with the result furnished by the consideration of the perihelion of Mars. More precision may be given to it by perfecting the theory of Mars, and by the discovery of new asteroids. Such as it is, it seems fitted to throw some light upon a subject in regard to which we have hitherto had no reliable data.

In a second memoir* the author establishes by a thorough investigation of the secular variations of the elements of the orbits the following propositions.

1. The excentricities of the orbits of the known asteroids can suffer only very small changes as the effect of perturbation.

* Compt. Rend., t. xxxvii, p. 965.

These excentricities which are now quite large, have then always been and will always remain large.

2. The same is true of the inclination of their orbits. So that the amount of excentricity and inclination answers to the primitive conditions of the formation of the group.

3. These propositions are true only for distances from the sun above 2·00. An asteroid situated between Mars and the distance of about 2·00 would not be *stable* in the meaning which is attached to that word in celestial mechanics.

Flora, which is nearest to the sun of the known asteroids, is 2·20 distant. The author observes that it is quite remarkable that a planet has been found almost up to the line which theory assigns as the limit of stability, and that none have been found beyond it. Must we believe that the same cause which has given origin to so many asteroids above the distance 2·00 has also distributed them below this distance? but that, the excentricities and inclinations of these last being considerably increased, it is at present difficult to discover them, especially because towards their perihelion, they will be immersed in the light of the sun, and that coming to their opposition only near their aphelia, they will then be too far from us?

4. Owing to the magnitude of the excentricities and the inclinations and the smallness of their variations, the mean motions of the perihelia and of the nodes are proportional to the times.

ART. XIII.—*On Electric Induction—Associated cases of Current and Static Effects;* by Professor FARADAY, D.C.L., F.R.S.*

CERTAIN phenomena that have presented themselves in the course of the extraordinary expansion which the works of the Electric Telegraph Company have undergone, appeared to me to offer remarkable illustrations of some fundamental principles of electricity, and strong confirmation of the truthfulness of the view which I put forth sixteen years ago, respecting the mutually dependent nature of induction, conduction, and insulation (Experimental Researches, 1318, &c.). I am deeply indebted to the Company, to the Gutta Percha Works, and to Mr. Latimer Clarke, for the facts; and also for the opportunity both of seeing and showing them well.

Copper wire is perfectly covered with gutta percha at the Company's works, the metal and the covering being in every part regular and concentric. The covered wire is usually made into half-mile lengths, the necessary junctions being effected by twisting or binding, and ultimately soldering; after which the place

* Phil. Mag., 4th Ser., vii, 197, March, 1854.

is covered with fine gutta percha, in such a manner as to make the coating as perfect there as elsewhere: the perfection of the whole operation is finally tried in the following striking manner by Mr. Statham, the manager of the works. The half-mile coils are suspended from the sides of barges floating in a canal, so that the coils are immersed in the water whilst the two ends of each coil rise into the air: as many as 200 coils are thus immersed at once; and when their ends are connected in series, one great length of 100 miles of submerged wire is produced, the two extremities of which can be brought into a room for experiment. An insulated voltaic battery of many pairs of zinc and copper, with dilute sulphuric acid, has one end connected with the earth, and the other, through a galvanometer, with either end of the submerged wire. Passing by the first effect, and continuing the contact, it is evident that the battery current can take advantage of the whole accumulated conduction or defective insulation in the 100 miles of gutta percha on the wire, and that whatever portion of electricity passes through to the water will be shown by the galvanometer. Now the battery is made one of intensity, in order to raise the character of the proof, and the galvanometer employed is of considerable delicacy; yet so high is the insulation, that the deflection is not more than 5°. As another test of the perfect state of the wire, when the two ends of the battery are connected with the two ends of the wire, there is a powerful current of electricity shown by a much coarser instrument; but when any one junction in the course of the 100 miles is separated, the current is stopped, and the leak or deficiency of insulation rendered as small as before. The perfection and condition of the wire may be judged of by these facts.

The 100 miles, by means of which I saw the phenomena, were thus good as to insulation. The copper wire was $\frac{1}{16}$th of an inch in diameter; the covered wire was $\frac{4}{16}$ths; some was a little less, being $\frac{7}{32}$nds in diameter; the gutta percha on the metal may therefore be considered as 0·1 of an inch in thickness. 100 miles of like covered wire in coils were heaped up on the floor of a dry warehouse and connected in one series, for comparison with that under water.

Consider now an insulated battery of 360 pairs of plates (4×3 inches) having one extremity to the earth; the water wire with both its insulated ends in the room, and a good earth discharge wire ready for the requisite communication: when the free battery end was placed in contact with the water wire and then removed, and afterwards a person touching the earth discharge touched also the wire, he received a powerful shock. The shock was rather that of a voltaic than of a Leyden battery; it occupied *time*, and by quick tapping touches could be divided into numerous small shocks; I obtained as many as forty sensible

shocks from one charge of the wire. If *time* were allowed to intervene between the charge and discharge of the wire, the shock was less; but it was sensible after two, three, or four minutes, or even a longer period.

When, after the wire had been in contact with the battery, it was placed in contact with a Statham's fuse, it ignited the fuse (or even six fuses in succession) vividly; it could unite the fuse three or four seconds after separation from the battery. When, having been in contact with the battery, it was separated and placed in contact with a galvanometer, it affected the instrument very powerfully; it acted on it, though less powerfully, after the lapse of four or five minutes, and even affected it sensibly twenty or thirty minutes after it had been separated from the battery. When the insulated galvanometer was permanently attached to the end of the water wire, and the battery pole was brought in contact with the free end of the instrument, it was most instructive to see the great rush of electricity into the wire; yet after that was over, though the contact was continued, the deflection was not more than 5°, so high was the insulation. Then separating the battery from the galvanometer, and touching the latter with the earth wire, it was just as striking to see the electricity rush out of the wire, holding for a time the magnet of the instrument in the reverse direction to that due to the ingress or charge.

These effects were produced equally well with either pole of the battery or with either end of the wire; and whether the electric condition was conferred and withdrawn at the same end, or at the opposite ends of the 100 miles, made no difference in the results. An intensity battery was required, for reasons which will be very evident in the sequel. That employed was able to decompose only a very small quantity of water in a given time. A Grove's battery of eight or ten pairs of plates, which would have far surpassed it in this respect, would have had scarcely a sensible power in affecting the wire.

When the 100 miles of wire in the air were experimented with in like manner, not the slightest signs of any of these effects were produced. There is reason, from principle, to believe that an infinitesimal result is obtainable, but as compared to the water wire the action was nothing. Yet the wire was equally well and better insulated, and as regarded a constant current, it was an equally good conductor. This point was ascertained by attaching the end of the water wire to one galvanometer, and the end of the air wire to another like instrument; the two other ends of the wires were fastened together, and to the earth contact; the two free galvanometer ends were fastened together, and to the free pole of the battery: in this manner the current was divided between the air and water wires, but the galvanometers were affected to precisely the same amount. To make the result more

certain, these instruments were changed one for the other, but the deviations were still alike; so that the two wires conducted with equal facility.

The cause of the first results is, upon consideration, evident enough. In consequence of the perfection of the workmanship, a Leyden arrangement is produced upon a large scale; the copper wire becomes charged statically with that electricity which the pole of the battery connected with it can supply;* it acts by induction through the gutta percha (without which induction it could not itself become charged, Exp. Res. 1177), producing the opposite state on the surface of the water touching the gutta percha, which forms the outer coating of this curious arrangement. The gutta percha across which the induction occurs is only 0·1 of an inch thick, and the extent of the coating is enormous. The surface of the copper wire is nearly 8300 square feet, and the surface of the outer coating of water is four times that amount, or 33,000 square feet; hence the striking character of the results. The intensity of the static charge acquired is only equal to the intensity at the pole of the battery whence it is derived; but its quantity is enormous, because of the immense extent of the Leyden arrangement; and hence when the wire is separated from the battery and the charge employed, it has all the powers of a considerable voltaic current, and gives results which the best ordinary electric machines and Leyden arrangements cannot as yet approach.

That the air wire produces none of these effects is simply because there is no outer coating correspondent to the water, or only one so far removed as to allow of no sensible induction, and therefore the inner wire cannot become charged. In the air wire of the warehouse, the floor, walls, and ceiling of the place constituted the outer coating, and this was at a considerable distance; and in any case could only affect the outside portions of the coils of wire. I understand that 100 miles of wire, stretched in a line through the air so as to have its whole extent opposed to earth, is equally inefficient in showing the effects, and there it must be the distance of the inductric and inducteous surfaces (1483), combined with the lower specific inductive capacity of air, as compared with gutta percha, which causes the negative result. The phenomena altogether offer a beautiful case of the identity of static and dynamic electricity. The whole power of a considerable battery may in this way be worked off in separate portions, and measured out in units of static force, and yet be employed afterwards for any or every purpose of voltaic electricity.

I now proceed to further consequences of associated static and dynamic effects. Wires covered with gutta percha and then inclosed in tubes of lead or of iron, or buried in the earth, or sunk

* Davy, Elements of Chemical Philosophy, p. 154.

in the sea, exhibit the same phenomena as those described, the like static inductive action being in all these cases permitted by the conditions. Such subterraneous wires exist between London and Manchester; and when they are all connected together so as to make one series, offer above 1500 miles; which, as the duplications return to London, can be observed by one experimenter at intervals of about 400 miles, by the introduction of galvanometers at these returns. This wire, or the half or fourth of it, presented all the phenomena already described; the only difference was, that as the insulation was not so perfect, the charged condition fell more rapidly. Consider 750 miles of the wire in one length, a galvanometer *a* being at the beginning of the wire, a second galvanometer *b* in the middle, and a third *c* at the end; these three galvanometers being in the room with the experimenter, and the third *c* perfectly connected with the earth. On bringing the pole of the battery into contact with the wire through the galvanometer *a*, that instrument was instantly affected; after a sensible time *b* was affected, and after a still longer time *c*: when the whole 1500 miles were included, it required two seconds for the electric stream to reach the last instrument. Again; all the instruments being deflected (of course not equally, because of the electric leakage along the line), if the battery were cut off at *a*, that instrument instantly fell to zero; but *b* did not fall until a little while after; and *c* only after a still longer interval,—a current flowing on to the end of the wire whilst there was none flowing in at the beginning. Again; by a short touch of the battery pole against *a*, it could be deflected and could fall back into its neutral condition before the electric power had reached *b*; which in its turn would be for an instant affected, and then left neutral before the power had reached *c*; a wave of force having been sent into the wire which gradually travelled along it, and made itself evident at successive intervals of time in different parts of the wire. It was even possible, by adjusted touches of the battery, to have two simultaneous waves in the wire following each other, so that at the same moment that *c* was affected by the first wave, *a* or *b* was affected by the second; and there is no doubt that by the multiplication of instruments and close attention, four or five waves might be obtained at once.

If after making and breaking battery contact at *a*, *a* be immediately connected with the earth, then additional interesting effects occur. Part of the electricity which is in the wire will return, and passing through *a* will deflect it in the reverse direction; so that currents will flow out of both extremities of the wire in opposite directions, whilst no current is going into it from any source. Or if *a* be quickly put to the battery and then to the earth, it will show a current first entering into the wire, and

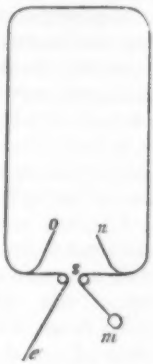
then returning out of the wire at the same place, no sensible part of it ever travelling on to *b* or *c*.

When an air wire of equal extent is experimented with in like manner, no such effects as these are perceived; or if, guided by principle, the arrangements are such as to be searching, they are perceived only in a very slight degree, and disappear in comparison with the former gross results. The effect at the end of the very long air wire (or *c*) is in the smallest degree behind the effect at galvanometer *a*; and the accumulation of a charge in the wire is not sensible.

All these results as to *time*, &c. evidently depend upon the same condition as that which produced the former effect of static charge, namely, *lateral induction;* and are necessary consequences of the principles of conduction, insulation and induction, three terms which in their meaning are inseparable from each other (Exp. Res. 1320, 1326,* 1338, 1561, &c.). If we put a plate of shell-lac upon a gold-leaf electrometer and a charged carrier (an insulated metal ball of two or three inches diameter) upon it, the electrometer is diverged; removing the carrier, this divergence instantly falls, this is *insulation* and *induction:* if we replace the shell-lac by metal, the carrier causes the leaves to diverge as before; but when removed, though after the shortest possible contact, the electroscope is left diverged,—this is *conduction*. If we employ a plate of spermaceti, instead of the metal, and repeat the experiment, we find the divergence partly falls and partly remains, because the spermaceti insulates and also conducts, doing both imperfectly: but the shell-lac also conducts, as is shown if time be allowed; and the metal also obstructs conduction, and therefore insulates, as is shown by simple arrangements. For if a copper wire, 74 feet in length, and $\frac{1}{13}$th of an inch in diameter, be insulated in the air, having its end *m* a metal ball; its end *e* connected with the earth, and the parts near *m* and *e* brought within half an inch of each other, as at *s*; then an ordinary Leyden jar being charged sufficiently, its outside connected with *e* and its inside with *m*, will give a charge to the wire, which

* 1326. All these considerations impress my mind strongly with the conviction, that insulation and ordinary conduction cannot be properly separated when we are examining into their nature; that is, into the general law or laws under which their phenomena are produced. They appear to me to consist in an action of contiguous particles, dependent on the forces developed in electrical excitement: these forces bring the particles into a state of tension or polarity, which constitutes both *induction* and *insulation;* and being in this state, the contiguous particles have a power or capability of communicating these forces, one to the other, by which they are lowered and discharge occurs. Every body appears to discharge (444, 987); but the possession of this capability in a *greater or smaller degree* in different bodies makes them better or worse conductors, worse or better insulators: and both *induction* and *conduction* appear to be the same in their principle and action (1320), except that in the latter an effect common to both is raised to the highest degree, whereas in the former it occurs in the best cases, in only an almost insensible quantity.

instead of travelling wholly through it, though it be so excellent a conductor, will pass in large proportion through the air at *s*, as a bright spark; for with such a length of wire, the resistance in it is accumulated until it becomes as much, or perhaps even more, than that of the air, for electricity of such high intensity.



Admitting that such and similar experiments show that conduction through a wire is preceded by the act of induction (1338), then all the phenomena presented by the submerged or subterranean wires are explained; and in their explanation confirm, as I think, the principles given. After Mr. Wheatstone had, in 1834, measured the velocity of a wave of electricity through a copper wire, and given it as 288,000 miles in a second, I said, in 1838, upon the strength of these principles (1333), "that the velocity of discharge through the *same wire* may be greatly varied, by attending to the circumstances which cause variations of discharge through spermaceti or sulphur. Thus, for instance, it must vary with the tension or intensity of the first urging force, which tension is charge and induction. So if the two ends of the wire in Professor Wheatstone's experiment were immediately connected with two large insulated metallic surfaces exposed to the air, so that the primary act of induction, after making the contact for discharge, might be in part removed from the internal portion of the wire at the first instant, and disposed for the moment on its surface jointly with the air and surrounding conductors, then I venture to anticipate that the middle spark would be more retarded than before; and if these two plates were the inner and outer coating of a large jar, or a Leyden battery, then the retardation of that spark would be still greater." Now this is precisely the case of the submerged or subterraneous wires, except that instead of carrying their surfaces towards the inducteous coatings (1483), the latter are brought near the former; in both cases the induction consequent upon charge, instead of being exerted almost entirely at the moment within the wire, is to a very large extent determined externally; and so the discharge or conduction being caused by a lower tension, therefore requires a longer time. Hence the reason why, with 1500 miles of subterraneous wire, the wave was two seconds in passing from end to end; whilst with the same length of air wire, the time was almost inappreciable.

With these lights it is interesting to look at the measured velocities of electricity in wires of metal, as given by different experimenters.

	Miles per second.
* Wheatstone, in 1834, with copper wire made it	288,000
* Walker, in America, with telegraph iron wire	18,780
* O'Mitchell, do. do. do.	28,524
* Fizeau and Gonnelle (copper wire) - -	112,680
* Do. (iron wire) - - -	62,600
† A. B. G. (copper) London and Brussels Telegraph	2,700
† Do. (copper) London and Edinburgh Telegraph	7,600

Here the difference in copper is seen by the first and sixth results to be above a hundred fold. It is further remarked in Liebig's report of Fizeau and Gonnelle's experiments, that the velocity is not proportional to the conductive capacity, and is independent of the thickness of the wire. All these circumstances and incompatibilities appear rapidly to vanish, as we recognize and take into consideration the lateral induction of the wire carrying the current. If the velocity of a brief electric discharge is to be ascertained in a given length of wire, the simple circumstances of the latter being twined round a frame in small space, or spread through the air through a large space, or adhering to walls, or lying on the ground, will make a difference in the results. And in regard to long circuits, such as those described, their conducting power cannot be understood whilst no reference is made to their lateral static induction, or to the conditions of intensity and quantity which then come into play; especially in the case of short or intermitting currents, for then static and dynamic are continually passing into each other.

It has already been said, that the conducting power of the air and water wires are alike for a constant current. This is in perfect accordance with the principles and with the definite character of the electric force, whether in the static, or current, or transition state. When a voltaic current of a certain intensity is sent into a long water wire, connected at the further extremity with the earth, part of the force is in the first instance occupied in raising a lateral induction round the wire, ultimately equal in intensity at the near end to the intensity of the battery stream, and decreasing gradually to the earth end, where it becomes nothing. Whilst this induction is rising, that within the wire amongst its particles is beneath what it would otherwise be; but as soon as the first has attained its maximum state, then that in the wire becomes proportionate to the battery intensity, and therefore equals that in the air wire, in which the same state is (because of the absence of lateral induction) almost instantly attained. Then of course they discharge alike, and therefore conduct alike.

A striking proof of the variation of the conduction of a wire by variation of its lateral static induction is given in the experi-

* Liebig and Kopp's Report, 1850 (translated), p. 168.
† Athenæum, January 14, 1854, p. 54.

ment proposed sixteen years ago (1333). If, using a constant charged jar, the interval *s*, page 90, be adjusted so that the spark shall freely pass there (though it would not if a little wider), whilst the short connecting wires *n* and *o* are insulated in the air, the experiment may be repeated twenty times without a single failure; but if after that, *n* and *o* be connected with the inside and outside of an insulated Leyden jar, as described, the spark will never pass across *s*, but all the charge will go round the whole of the long wire. Why is this? The quantity of electricity is the same, the wire is the same, its resistance is the same, and that of the air remains unaltered; but because the intensity is lowered, through the lateral induction momentarily allowed, it is never enough to strike across the air at *s*; and it is finally altogether occupied in the wire, which in a little longer time than before effects the whole discharge. M. Fizeau has applied the same expedient to the primary voltaic currents of Ruhmkorff's beautiful inducting apparatus with great advantage. He thereby reduces the intensity of these currents at the moment when it would be very disadvantageous, and gives us a very striking instance of the advantage of viewing static and dynamic phenomena as the result of the same laws.

Mr. Clarke arranged a Bain's printing telegraph with three pens, so that it gave beautiful illustrations and records of facts like those stated: the pens are iron wires, under which a band of paper imbued with ferro-prussiate of potassa passes at a regular rate by clock-work; and thus regular lines of prussian blue are produced whenever a current is transmitted, and the time of the current is recorded. In the case to be described, the three lines were side by side, and about 0·1 of an inch apart. The pen *m* belonged to a circuit of only a few feet of wire and a separate battery; it told whenever the contact key was put down by the finger; the pen *n* was at the earth end of the long air wire, and the pen *o* at the earth end of the long subterraneous wire; and by arrangement, the key could be made to throw the electricity of the chief battery into either of these wires, simultaneously with the passage of the short circuit current through pen *m*. When pens *m* and *n* were in action, the *m* record was a regular line of equal thickness, showing by its length the actual time during which the electricity flowed into the wires; and the *n* record was an equally regular line, parallel to, and of equal length with the former, but the least degree behind it; thus indicating that the long air wire conveyed its electric current almost instantaneously to the further end. But when pens *m* and *o* were in action, the *o* line did not begin until some time after the *m* line, and it continued after the *m* line had ceased, *i. e.* after the *o* battery was cut off. Furthermore, it was faint at first, grew up to a maximum of intensity, continued at that as long as battery con-

tact was continued, and then gradually diminished to nothing. Thus the record *o* showed that the wave of power took time in the water wire to reach the further extremity; by its first faintness, it showed that power was consumed in the exertion of lateral static induction along the wire; by the attainment of a maximum and the after equality, it showed when this induction had become proportionate to the intensity of the battery current; by its beginning to diminish, it showed when the battery current was cut off; and its prolongation and gradual diminution showed the time of the outflow of the static electricity laid up in the wire, and the consequent regular falling of the induction which had been as regularly raised.

With the pens *m* and *o*, the conversion of an intermitting into a continuous current could be beautifully shown; the earth wire, by the static induction which it permitted, acting in a manner analogous to the fly-wheel of a steam-engine or the air-spring of a pump. Thus, when the contact key was regularly but rapidly depressed and raised, the pen *m* made a series of short lines separated by intervals of equal length. After four or more of these had passed, then pen *o*, belonging to the subterraneous wire, began to make its mark, weak at first, then rising to a maximum, but always continuous. If the action of the contact key was less rapid, then alternate thickening and attenuations appeared in the *o* record; and if the introductions of the electric current at the one end of the earth wire were at still longer intervals, the records of action at the other end became entirely separated from each other; all showing most beautifully how the individnal current or wave, once introduced into the wire, and never ceasing to go onward in its course, could be affected in its intensity, its time and other circumstances, by its partial occupation in static induction.

By other arrangements of the pens *n* and *o*, the near end of the subterraneous wire could be connected with the earth immediately after separation from the battery; and then the back flow of the electricity, and the time and manner thereof, were beautifully recorded; but I must refrain from detailing results which have already been described in principle.

Many variations of these experiments have been made and may be devised. Thus the ends of the insulated battery have been attached to the ends of the long subterraneous wire, and then the two halves of the wire have given back opposite return currents when connected with the earth. In such a case the wire is positive and negative at the two extremities, being permanently sustained by its length and the battery, in the same condition which is given to the short wire for a moment by the Leyden discharge (p. 90); or, for an extreme but like case, to a filament of shell-lac having its extremities charged positive and negative.

Coulomb pointed out the difference of long and short as to the insulating or conducting power of such filaments, and like difference occurs with long and short metal wires.

The character of the phenomena described in this report induces me to refer to the terms *intensity* and *quantity* as applied to electricity, terms which I have had so frequent occasion to employ. These terms, or equivalents for them, cannot be dispensed with by those who study both the static and the dynamic relations of electricity; every current where there is resistance has the static element and induction involved in it, whilst every case of insulation has more or less of the dynamic element and conduction; and we have seen that with the same voltaic source, the same current in the same length of the same wire gives a different result as the intensity is made to vary, with variations of the induction around the wire. The idea of intensity, or the power of overcoming resistance, is as necessary to that of electricity, either static or current, as the idea of pressure is to steam in a boiler, or to air passing through apertures or tubes; and we must have language competent to express these conditions and these ideas. Furthermore, I have never found either of these terms lead to any mistakes regarding electrical action, or give rise to any false view of the character of electricity or its unity. I can not find other terms of equally useful significance with these; or any, which, conveying the same ideas, are not liable to such misuse as these may be subject to. It would be affectation, therefore, in me to search about for other words; and besides that, the present subject has shown me more than ever their great value and peculiar advantage in electrical language.

Note.—The fuse referred to in page 86 is of the following nature:—Some copper wire was covered with sulphuretted gutta percha; after some months it was found that a film of sulphuret of copper was formed between the metal and the envelope; and further that when half the gutta percha was cut away in any place, and then the copper wire removed for about a quarter of an inch, so as to remain connected only by the film of sulphuret adhering to the remaining gutta percha, an intensity battery could cause this sulphuret to enter into vivid ignition, and fire gunpowder with the utmost ease. The experiment was shown in the lecture-room, of firing gunpowder at the end of eight miles of single wire. Mr. Faraday reported that he had seen it fired through 100 miles of covered wire immersed in the canal by the use of this fuse.

ART. XIV.—*Reclamation of Borocalcite, as distinct from a mixture of minerals, found near Iquique, South Peru;* by AUG. A. HAYES, M.D., Assayer to the State of Massachusetts.

THIS mineral which was early analyzed and described by myself, has under the name of Teza, been confounded by Messrs. Ulex and Lecanu with other minerals which occur with it in the same bed. These chemists have apparently analyzed the minerals, constituting distinct species, together, without that careful separation mechanically, which should always precede a chemical analysis.

The parcel I originally received from John H. Blake, Esq., weighed several hundred pounds, and the existence of other salts with the borocalcite, was pointed out by me in detail. Yet, there were nodular masses frequently found, containing mere traces of other compounds, and quite as pure as commercial salts in general.

Supposing that future explorations had shown a more intimate union of the different salts, I have refrained from noticing the discordant results obtained by others, until the mineral as an article of commercial importance, should come to my hands.

Within a few weeks, the "muster" samples of two hundred tons have been sent to me, and I give the results obtained by careful analysis of these, as follows:

Water of crystallization, - - -	27·16
Anhydrous borate of lime, - - -	41·34
Glauberite, - - - - -	23·20
Chlorid of sodium, - - - -	6·40
Sand, - - - - - -	1·90
	100·00

Some samples could be differently reported, but the point which I deemed essential, after reading the statement of M. Lecanu was, the absolute proof obtained by different modes of analysis, of the *entire absence of any borate of soda*, in the samples. The Glauberite and common salt are mere mixtures, apparent on inspection, and most easily separable by washing,—the borate of lime in the form of silky fibres being suspended in the water, and when collected and analyzed, giving the same proportions of acid and base, as the salt artificially formed.

As a source of boracic acid, in the manufacture of borax, I have already called public attention to this mineral, and it is now seeking the markets of the world, in large quantities.

16 Boylston St., Boston, 3d Apr. 1854.

ART. XV.—*On the present condition of the Crater of Kilauea, Hawaii;* by Rev. TITUS COAN.*

KILAUEA is still quiet. Many parties have visited the crater during the past year, and of these I have made special inquiries, as I have not been able to visit it myself. Changes have been slowly taking place within the crater. The aperture in the summit of the great dome which covers the igneous lake,† is gradually enlarging by the falling of avalanches from its walls, and thus revealing more and more of the fiery abyss below. But the melted lava does not approach the top of the dome. It is still 150 feet below, and you see it as you see the fire in the bottom of a coal-pit, by looking down through an orifice in the summit. The dome is probably two miles in circuit at its base, and some 400 feet high. Steam and smoke are constantly escaping from numerous holes and fissures in the dome, and the whole resembles a vast coal-kiln in the process of charring. On the western side of the dome a large fissure has been opened from the base to near the rim of the orifice at the summit, and from this rent, near the base, streams of lava have been occasionally poured out, inundating the area around the dome. This lateral outlet has prevented the lake from rising and flowing off at the summit orifice. Several other small lakes have been opened and closed at different points in the crater during the past year. These have varied from one-fourth of an acre to two acres in area, and their action has varied in intensity. A number of cones have also been thrown up in different parts of the crater, and there are evidences of partial overflowings in many places over the bottom of Kilauea. But these changes have occurred when no one was present to witness them.

A gradual rising is going on in the whole floor of the crater. This is effected by two causes—first, by the lifting forces below, as gases, igneous fusion, etc., and second, by eruptive overflowings: the former is more uniform and general—the latter irregular and partial. Every thing is silently preparing for another grand eruption; but when this will occur, at what point, under what circumstances, and with what effects, no one can tell.

You are aware that all the central part of the floor of the crater, embracing nearly one half of its area, is an elevated plateau, the highest points of which are now some 600 feet above what was the floor after the eruption of 1840. This central elevation rises in some places gradually, in others abruptly, from the surrounding floor. On the east and southeast its mural walls are perpendicular, presenting a dark, lofty, and frowning rampart,

* From a letter to J. D. Dana, dated Hilo, Hawaii, Jan. 30, 1854.

† The lake referred to occupies the southern end of the large area that forms the bottom of the crater of Kilauea.—D.

which no human foot can scale. At some points, immense avalanches have fallen from these high battlements, forming a steep inclined plane of confused and toppling debris, from the base of the walls two-thirds of the way up to their summits. On the north and west the elevation is less and less abrupt, and the plateau can be ascended from these points.

This central "table-rock," as will be seen, is surrounded by what used to be called "The Black Ledge," embracing all that portion of the crater which was sunk to the depth of 400 feet during the eruption of 1840. Of course "the Black Ledge" is now a lower plane than this central table, at its highest points, by about 200 feet. Many parts of "the Black Ledge," have also been elevated by local overflowings, and all of it, probably, by subterranean forces.

Occasionally the light of Kilauea is seen along the shores of Hawaii; but these exhibitions have been faint and few since 1840—a result of the roofing over of Halemaumau (the great lake). It may be doubted whether Kilauea will ever again assume its former activity and grandeur. From repeated agitations of the sea around our shores,—instances of which have recently occurred—we are led to think that submarine eruptions are occasionally taking place on the submerged portions of Hawaii, or from volcanic mountains and cones covered by the waters of the Pacific. These hidden eruptions will, doubtless, add to the dry land in our ocean in due time. Should there be a connection and a sympathy between these lower eruptive points and those above us, we may argue a diminution of the upper fires in proportion to the intensity of the submarine; and yet this may not follow, as we have magnificent eruptions on Mauna Loa, while Kilauea sleeps. These phenomena have puzzled me; but the solution you have given in your admirable work on geology satisfies my mind better than any theory I have seen.

All is quiet at Mauna Loa. The eruption of 1852 still steams a little at a few points in the woods back of us, not half so much however, as the eruption of 1840. There are points on this line, (that of 1840,) midway from Kilauea to the sea, where there are still much smoke and heat.

You ask if there were any small cones thrown up along the stream in the eruption of 1852. There were a few, but none of much size, so far as I explored. You are aware that the eruption commenced on the 17th of February, on the summit of Mauna Loa. In two days this valve closed, and the summit action ceased. On the 20th the lateral valve opened, 4000 feet below the top of the mountain, and the thundering torrent of fire rushed out and continued its awful disgorgement for twenty days. Between the summit point and the lower one, the ribs of the moun-

tain were rent, and seams and fissures were opened by the expansive force of the internal fire, as it forced its way in subterranean chambers down the sides of the mountain to the point of final eruption. Along the line of this covered duct an occasional jet was thrown up through a fissure to the surface, and in some places small cones were raised like warts on the side of the mountain. Many such were formed by the grand eruption of 1843, an account of which you have probably seen,—and the exploration of which was one of the most arduous and perilous I have ever undertaken. You will recollect that this eruption, (1843,) when it had flowed down the northern surface of the mountain for some two weeks, extending about thirty miles in length, with a breadth of from one to three miles, suddenly solidified on its surface, like a frozen river, still continuing its flow for weeks in a subterranean canal from the top of Mauna Loa to the base of Mauna Kea, throwing off lateral streams to the west and northwest. On this stream cones were thrown up from thirty to seventy feet high, usually with an orifice in the top, down which you could look and see the noiseless river of igneous rock, fused to whiteness, and gliding under your feet at the rate of a steam ship.

ART. XVI.—*Note on the genus Buckleya*; by ASA GRAY, M.D.

IN a foot-note on page 170 of the 45th volume of this Journal (eleven years ago) is published a brief character of an interesting Santalaceous genus, founded on the *Borya distichophylla* of Nuttall, and named *Buckleya* by Dr. Torrey, in compliment to Mr. S. B. Buckley, who first collected and communicated specimens with the fructification. Although specimens were collected about the same time by Mr. Rugel, and doubtless distributed in Europe, as were fruiting specimens gathered by Mr. Sullivant and myself in the autumn of 1843, I am not aware that the genus has been mentioned in any botanical work, or that any further knowledge has been gained respecting it, except the little which I have now to communicate.

In the year 1843, I was fortunate enough to procure and transport to Cambridge several living plants. Some of them were immediately sent to the Royal Botanic Gardens at Kew; but they probably perished in the voyage. Of those retained only one survived in our botanic garden; where it is perfectly hardy, and forms a shrub of 6 or 7 feet in height, remarkable for its neat habit, slender green boughs, and pretty distichous leaves. It proved to be a female plant; and has flowered and produced abortive fruit for the last two or three years, in the form of a fusiform pericarp, crowned with four elongated and foliaceous calycine lobes. But the greenish flowers, although not very small,

are so inconspicuous that they have until now escaped my notice at the proper season for examining them.

The point of principal consequence is that the female flowers prove to have a *double perigonium;* one, moreover, in which the exterior or "accessory calyculus," far from being minute or rudimentary, is much more conspicuous than the inner, being of more than twice its length! The divisions of this accessory perigonium are regularly alternate with the inner or normal perigonium of the family, that which is opposed to the stamens, and which manifestly answers to the single floral envelope in the allied *Pyrularia*. But they so perfectly resemble the leaves in shape and texture, (although narrower as well as smaller,) as also in vernation, expanding with the leaves some days before the inner perigonium opens, that they do not perhaps suggest much argument, in addition to what is already furnished by *Olacineæ* and *Loranthus*, for changing the generally received view of the nature of the floral covering in *Santalaceæ*. Their foliaceous nature is further evinced by their distinct articulation with the summit of the calyx-tube. These long and narrow lobes are the "perigonium" of Dr. Torrey's character of the genus, at least of the female flowers; the proper perigonium having probably fallen in the specimens he examined, although it is by no means very deciduous. I have not seen the male flowers.

A second peculiarity of *Buckleya* relates to the æstivation of the inner or proper floral envelope; which is not valvate, as in all other known Santalaceous genera, but *imbricative*, decidedly, though not very strongly so.

A third but slighter discrepancy from the general character of the *Santalaceæ*, as commonly stated, is found in the opposite or sub-opposite leaves. These are said, in the published character of Buckleya, to be alternate: but they are placed, for the most part, in pairs on the slender branchlets, the whole much resembling the leaflets of a pinnate leaf, and the two leaves of each pair are either somewhat disjoined, or as frequently exactly opposite, at least on the upper part of the branchlets. The leaves are more strictly opposite in *Darbya*, *Fusanus*, and *Santalum* itself.

It might be urged, apparently on very strong grounds, that a plant whose floral envelopes (at least in the male flowers) are distinctly double, and the inner series imbricated in æstivation, cannot belong to the order *Santalaceæ;* the more so as it is said in the published character to have a uniovulate ovary. This character, however, may have been merely inferred from the solitary seed, or *fertilized* ovule; and it is evident from the absence of the inner perigonium that the female flowers examined were in an advanced state. A dissection of the unimpregnated flowers in the living plant brings to view in *Buckleya* the ordinary struc-

ture of the Santalaceous ovarium. The small cell, if it may be so called, where there is no empty cavity, is filled by a short, oval or olong, erect central column, which bears near its free apex four very minute and simple ovules, evidently reduced to naked nuclei. This genus therefore undoubtedly belongs to the small alliance or class that comprises the *Olacineæ* and the *Santalaceæ;* and as respects these two orders I should not hesitate to refer it to the latter, notwithstanding the double floral envelopes. The moderate imbrication of the divisions of the perigonium in the bud is surely a discrepancy of slight importance in comparison with this characteristic ovulation; and I cannot but recognize in this case something like a direct confirmation of the opinion I had already ventured to express (Botany of the U. S. Expl. Exped. i, p. 301), namely, that Mr. Miers, in excluding on such grounds *Bursinopetalum* and *Pleuropetalon* from his order *Icacineæ*, has over-estimated the importance of a character which, however valuable, is seldom perfectly stable throughout all the members of a natural order.

As respects the female flowers of *Buckleya*, it therefore appears that the published character should be modified as follows:

Fl. fœm.: Perigonium basi quadribracteolatum; tubo clavato cum ovario connato; limbo duplici, utroque quadrisecto, laciniis exterioris (calyculi accessorii) linearibus foliaceis tubo sublongioribus diu persistentibus, interioris triangulari-ovatis æstivatione modice imbricatis exterioribus plus dimidio brevioribus deciduis. Discus epigynus planus, quadrangulatus, angulis parum liberis perigonii interioris laciniis alternantibus. Stamina nulla. Stylus brevissculus: stigma cruciato-quadrilobum, lobis perigonii interioris laciniis oppositis. Ovarium uniloculare. Ovula 3 vel 4, minima, simplicissima, ex apice placentæ centralis crassæ liberæ (loculum parvum implentis) pendula.

ART. XVII.—*On a mode of giving permanent flexibility to brittle specimens in Botany and Zoology;* by Prof. J. W. BAILEY, U. S. Military Academy, West Point, N. Y.

THE excessive fragility in the dry state, of many plants, and particularly of those which secrete carbonate of lime is well known to botanists. There is no herbarium in existence in which the specimens of Amphiroa, Jania, Corallina, Halimeda, Liagora, Chara, &c. are not in a more or less mutilated condition, which becomes worse every time the plants are examined. In studying a large collection of the stony Algæ I was led to remark their perfect flexibility while moist, which passed to great brittleness when dry, and it occurred to me that if they could be kept permanently moist they would remain permanently flexible.

I then remembered that General Totten, of the U. S. Engineers, had mentioned to me, some years ago, his success in preventing the cracking and peeling off of the epidermis of various shells, by impregnating them with chlorid of calcium. I also remembered Boucherie's experiments with the same substance in giving flexibility to wood. The principle that *a substance which is flexible when moist, will remain permanently moist, and therefore permanently flexible, when impregnated with a deliquescent salt,* is so obviously true that it needed no experiments to convince me of its applicability to the fragile plants above mentioned, and to many other specimens in natural history. But as practical difficulties often occur in the application of correct principles, I have tested the process by numerous experiments in which chlorid of calcium was employed to give flexibility to various vegetable and animal products, and the results have fully equalled my expectations. My specimens of Amphiroa, Jania, Corallina, &c. after being impregnated with this salt, and then exposed for months to the air, can be handled as freely as if just taken from the water, and they permanently retain almost the utmost degree of pliability they are capable of receiving. Species of dry, crisp and brittle Lichens when treated in the same way became soft, elastic, and flexible, so as to bear very rough handling with perfect impunity. Many of the common Algæ which shrink much in drying, and therefore assume a very unnatural appearance, and besides are apt either to become cracked or torn, or to wrinkle up the paper to which they adhere, retain after immersion in this salt, nearly their normal degree of distention, and preserve a much more natural appearance than when dried in the usual way. Many dried specimens of plants whose leaves, flowers or fruit, drop off almost at a touch from specimens in my herbarium, became permanently pliable when immersed for a short time in a solution of chlorid of calcium, and could then at any time be handled freely, while their appearance was in no degree injured.

In the animal kingdom, the results obtained in restoring permanent flexibility to dry and brittle specimens of Crustaceans, Insects, Gorgonias, Sponges, &c. were equally satisfactory, and have convinced me that almost every naturalist will, in his own department, find many useful applications for this process.

The *mode of application* which I have employed is to immerse the dry specimen for some time in a neutral saturated solution of chlorid of calcium, (which any one can make for himself by saturating chloro-hydric acid with marble,) and then after the specimen has become sufficiently softened to bend easily, remove it and let it drain in the open air. In some cases where the specimens do not imbibe the salt readily, it is well to soften them in warm water before immersion in the salt. A speedy impregnation will then take place, after which the specimens, if plants,

may be subjected to moderate pressure in the usual way, and restored to the herbarium, while other specimens may be kept on shelves or in any way usually employed for similar objects, and all will for any length of time retain sufficient moisture to prevent brittleness. The salt being neutral, no fear need be apprehended of its injuring color or texture, while its antiseptic properties will aid in the preservation of matters liable to decay.

ART. XVIII.—*Caricography;* by Prof. C. DEWEY.

(Continued from vol. ix, p. 30, Second Series.)

No. 243. *Carex aristata*, R. Br., var. *longo-lanceata*, Dew.

Pistillate scale oblong, long-awned or long-cuspidate, longer than the fruit; leaves, sheaths, and bracts scabro-pubescent.

Collected in the Mauvaises Terres (Bad Lands) of Nebraska Territory in 1853 by F. V. Hayden.

The common forms of C. aristata, R. Br. and of C. trichocarpa, Muh., appear abundant over that western country, with some tendency to unusual length of their scales, but in the above marked variety the scales are considerably longer than the fruit, and sometimes only very elongated lanceolate. Perhaps this plant should be held to be a distinct species,

No. 244. *C. nebrascencis*, Dew.

Spicis 4–6; staminiferis binis apicem approximatis oblongis brevibus densis, inferiore sessili parva, cum squamis oblongis subobtusis; pistilliferis 2–4, oblongis brevi-cylindraceis densifloris, superioribus apice staminiferis sessilibus, inferiore brevi-pedunculata; bracteis lanceolatis sessilibus culmum æquantibus; fructibus *distigmaticis* convexis obovatis vel ellipticis basin teretibus brevi-apiculatis ore sub-bilobis, squama ovata acuta vel lanceolata paulo brevioribus: culmo acute triquetro lævi basin foliato.

Culm 1-2 feet high, usually 16–20 inches, sharp-triquetrous, smooth, scarcely rough between the spikes, with lanceolate leaves towards the base shorter than the culm and soft, glabrous, serrulate on the edges, and with sessile bracts under the spikes as long as or longer than the culm above; staminate spikes two, oblong, close-flowered, short, lower one very short and sessile, with oblong and acutish scales: pistillate spikes 2–4, usually three, short, oblong, thick, erect, rarely an inch long, cylindric, densely flowered, sub-approximate, two upper sessile and often staminate at the apex, the lowest short pedunculate; stigmas two; fruit elliptic or obovate, slightly tapering at the base, short rostrate or round-apiculate, entire or sub-bilobed at the orifice, glabrous and double

convex; pistillate scale ovate, acute, or mucronate, sometimes lanceolate, narrower and once and a half longer than the fruit, tawny with a white line on the back.

No. 245. *C. Haydenii*, Dew.

Spicis 4–6, cylindraceis tenuibus; interdum quatuor, suprema staminifera, reliquis fructiferis; nunc staminifera unica vel binis, inferiore basin fructifera: pistilliferis 3–5, distigmaticis longo-cylindraceis erectis gracilibus laxifloris subremotis foliato-bracteatis, superiore vel pluribus apice staminifera, et infima brevi-pedunculata basin rariflora; fructibus ellipticis utrinque convexis apiculatis ore integris lævibus, squama lanceolata nigrescente dorso alba sub duplo brevioribus; culmo triquetro lævi basin foliaceo apicem scabro 2–3 pedali.

Culm triquetrous, erect, 2–3 feet high, smooth, scabrous above, leafy towards the base; spikes 4–6, cylindric, slender, erect; sometimes four, one staminate, and others nearly destitute of fruit; sometimes two staminate, the lower with fruit at the base, and four pistillate with the upper staminate at the apex, all long cylindric, 2–4 inches long, slender, erect, loose-flowered, leafy-bracteate, the lowest short-pedunculate and quite loose-flowered at the base; stigmas two; fruit oval or obovate, tapering at base, convex on both sides, short-rostrate or apiculate, entire at the orifice, smooth, often dark brown or nearly black in maturity; pistillate scale lanceolate, blackish with a white dorsal line, and nearly twice the length of the fruit.

On Missouri River near Fort Pierre; collected by Ferdinand V. Hayden in 1853, among the 1200 species of plants obtained while collecting fossils, &c. for Prof. James Hall, State Geologist, Albany. With the preceding three species of Carex were many others, all of which Prof. Hall politely put into my hands for examination.

Note.—The following species, just alluded to, were also collected by Dr. Hayden in that western region: C. eburnea, Boott; C. Meadii, Dew.; C. lanuginosa, Mx.; C. aristata, R. Br.; C. lacustris, Willd.; C. riparia, Good.; C. Shortii, Torr.; C. Muhlenbergii, Schk.; C. rosea, Schk. and its var. radiata, Dew., which was figured by Kunze for C. disperma, Dew., and was a great mistake; C. anceps, Muh.; C. straminea, Wahl.; C. Steudelii, Kth.; C. trichocarpa, Muh.; C. vesicaria, L.; C. festucacea, Schk.; C. grisea, Wahl.; C. stricta, Lam.; C. strictior, Dew.; C. mirabilis, Dew.; C. leporina, L., credited before by Boott to Arctic America; C. stenophylla, Wahl., found also by Dr. Richardson at Carlton House, and on Rocky Mountains, and abundant in Nebraska Ter.; C. marginata, Muh., exactly the form figured by Schk. in his fig. 143, and from which C. pennsylvanica, Lam. differs in its fruit and leaves; C. vulpinoidea, Mx.; C. stipata,

Muh.; C. vulpina, L., so exactly the European plant, that there can be no doubt of its correct determination in Ohio, and that the hesitation expressed by Dr. Boott in Richardson's Arctic Expedition, p. 466, is groundless, especially from any supposed resemblance to C. stipata, Muh., as the two are vastly different; C. Davisii, Tor.; C. longirostris, Tor.; and C. recta, Boott.

ART. XIX.—*Reviews and Records in Anatomy and Physiology;* by WALDO I. BURNETT, M.D., Boston.

I. PSOROSPERMIA.*

LIEBERKÜHN has furnished a communication of considerable length and detail on this subject, to which we refer particularly from its interesting relations. As a key to the article we may give his conclusions, as follows:

"The kidneys of some frogs contain cysts which enclose contents of very manifold characters, namely: 1. A peculiar, uniformly divided, granular mass. 2. This mass encompassed by small groups of an oval or fusiform shape. 3. Fusiform bodies, invested with a structureless membrane. 4. Developed psorospermatic corpuscles. These different objects are found wholly or partially in one and the same cyst. The mature psorospermial corpuscles usually contain three to five baton-like or ellipsoid or globular diaphanous corpuscles which are structureless; they usually have also a rather large nucleus. The diaphanous corpuscles are seen moving and springing in their capsules, and the nucleus is thereby moved about hither and thither. Such kidneys contain also free amœba-like corpuscles, and gregarina-like bodies largely nucleated."

These formations are by no means common,—our author having found them in four cases only out of a thousand specimens he has examined.

But in other animals, and in other organs he has found similar formations, as have others, such as Müller, Gluge, Leydig, before him. In fact, these psorospermial forms occur in both a free and a cystic state in different tissues.

The question is certainly a most interesting one: What signification shall be put upon these singular animal-like forms? But this is only one passage in the comprehensive question, What are most infusorial forms not evidently of a vegetable nature which every microscopist meets with perhaps daily in his studies? The subject certainly is not yet ripe for decision, but we may allude to it in a suggestive point of view. Both Kauffmann and Lieberkühn, in watching these Psorospermia in glasses on their tables,

* *N. Lieberkühn.* Ueber die Psorospermien, in *Müller's* Arch., 1854, Hft. 1, p. 1–25.

have observed that they multiply by a segmentation of their nucleus, and that the product of this division resembles precisely the parent. In some specimens observed by Lieberkühn, taken from a dog, he found the parent vesicle to contain sometimes 16 segmented globules. But here the observations unfortunately ceased, and we are not aware that in any case or instance they have been extended beyond this point; that is, so as to show that the offspring of this segmentation which so closely resembles its parent pursues the same course and produces by segmentation a third series. The doctrine that individual animal forms may be unicellular or that an animal may be composed solely of a single cell, as advanced by Siebold and Kölliker,* we regard as wholly untenable in the present state of science; for, aside from its being against the general analogy of individual zoological forms, it has not yet facts enough to sustain it merely as a point of observation. The cell is indeed typically the primordium of all organized forms, but true individual animal life seems to involve a cycle of relations not implied in single cells; in other words, these last must always lose their character as such in a definite form which belongs to the individual. Extended researches in Microscopy in all directions of the organic world,—all tend to establish the doctrine that sex lies behind all true individual forms,—that the ovum is the point of departure on one side, and the spermatic particle on the other,—and that by the conjunction of the two a new individuality is produced. There is indeed a most striking and beautiful uniformity between the simple cell and the ovum in a morphological point of view, or between the cell and the parent sperm-vesicle, thereby indicating a unity of idea and place in the first expression of life and the functional means of its cycle of actions; but without wishing to be mystical, it appears to us that life as expressed under the individual whether in its first or last forms,—as an egg ready to develope, or as a complete animal, rises high above and implies a great deal more than simple cell-conditions. We argue, then, that all true animals arise primarily or secondarily from ova, and therefore have sex, and that those animal-like forms so often seen as parasites or entozoa in animals must for the present stand undetermined, or if any interpretation is to be put upon them, they may be regarded as undeveloped forms of true animals, passing through various metamorphotic changes to which we have some clew in the remarkable phenomena of *alternation of generations.*

If the contents of the lower portion of the intestine of a frog be examined under the microscope, there will usually be found innumerable moving particles which give a very life-like aspect to the whole field. These belong to the infusorial genus *Bodo* of

* *Siebold* and *Kölliker.* See their Zeitsch. für wissenschaftliche Zoologie, I, p. 270, and ibid p. 1.

Ehrenberg. Examined with the highest and best microscopic powers, they are found to be composed of a more or less globular head to which is attached a thread-like tail of considerable length. This head taken by itself has all the appearances of a simple cell, —it is nucleated and even nucleolated; yet the whole body moves about by means of its tail in a most animal-like manner and in studying the field one can hardly divest the mind from the opinion that they are true animals.

The intestinal canal of many insects likewise, especially those feeding in damp, moist places, will often be found teeming with forms so large and numerous that it is singular that the insect should live. Many of these forms are composed of a more or less globular sac filled with a punctiform matter in which lies a round nucleus; at one extremity of this sac is an orifice surrounded by a circle of cilia. Others are more vermiform, regularly wrinkled, but apparently non-nucleated. These belong to the Gregarinæ, and are the forms upon which Siebold and Kölliker have based their doctrine of unicellular animals. Other instances might be cited, equally prominent, which almost daily come under the eye of the microscopist in his studies in the lower department of the animal kingdom.

Our own observations upon these objects have not led us to the view that they are, any of them, perfect individual forms;* on the other hand, research is constantly reducing their generic numbers, on the one side, by showing that many so-called genera are only different developments of one and the same form; and by removing them, on the other, from that *Receptaculum omnium animalium et plantarum*—the Infusoria—it being shown that they are only germs or larval forms of some of the inferior classes.† The recent investigations of Siebold and others, in Helminthology, to which we shall soon allude, have shown how varied may be the larval forms, how dissimilar from the true adult animal, and how remarkable the localities in which they occur, in the case of many of the Entozoa. In the case of the Psorospermia, or the Gregarinæ, or other forms which have been grouped under special genera or species, we must wait further research, and they will then, we think, be shown to be undeveloped forms. As to the question of the animal or vegetable nature of such organisms, it seems equally obscure, for the older criteria by which animals were separated from plants have long since been regarded as invalid; and some of those which in late years have been regarded as among the most constant, have quite recently been declared equally unsound.

* For *Bodo*, see Boston Journal of Natural History, vi, No. 3, 1853, p. 319.

† Thus *Agassiz* has shown that *Paramœcium* and *Bursaria*, &c. are only larval forms of Planariæ. See Annals of Nat. Hist., vi, 1850, p. 156. *Euglena*, *Amœba*, and others, will most probably meet with a like resolution.

Robin has argued that the Psorospermia are plants because they contain cellulose; but as the investigations of Kölliker, and of Löwig and Schacht have shown that this substance occurs indubitably in animal tissues, this can no longer be considered as a criterion.* We are reduced to *voluntary motion* as the only now known differential criterion on this subject, and as this must be a point on which different observers will vary, the subject must still remain unsettled; but we protest against any fusion of the two organic kingdoms on this obscure arena.

II. On the Mermithes.†

A memoir of great worth has recently appeared upon these singular parasites, which has a double importance of quite clearing up the history of these animals in all their stages, and of furnishing a contribution to the histology of the lower animals of a most valuable character. This memoir is by G. Meissner of München, under the direction of Siebold who furnished him with specimens and other opportunities for its successful prosecution. Seldom have we met with a paper of more careful and extended detail, and which leaves so little behind for investigators in the same direction. Added to this textual detail, each and every anatomical point is illustrated by admirably executed figures. With our limited space we can at best notice only a few of the more prominent points of this paper.

In the first place it should be remarked that the natural history of the Gordiacei was for a long time quite obscure and little understood, and many detached observations not of a parallel character did not improve the subject. To the sagacity of Siebold we are indebted for the successful resolution of the whole enigma, and the results he has obtained are as singular as new.‡ It appears that these animals live part of their life as a regular entozoon, and the rest as an independent being. And what is most remarkable, they enter the animals in which they are for a time parasites, not in the form of eggs, as do other Helminths, but as more or less developed forms. The animals in which they live as parasites are almost exclusively Insects of different orders in both the larva and imago state. In the abdominal cavity of the larvæ of *Yponomeuta albicans*, Siebold found numerous undeveloped forms of *Mermis albicans*. Watching them he found that after further growth, they perforated the skin of these larvæ and

* For full reference to the subject of cellulose in the tissues of the lower animals, see *Siebold* and *Stannius's* Comparative Anatomy, Amer. ed., vol. i, § 172.

† Beiträge zur Anatomie und Physiologie von Mermis albicans. Von Dr. *Georg Meissner*. In *Siebold* and *Kölliker's* Zeitschrift für wissenschaftliche Zoologie, v, 1853, p. 207–285.

‡ *Siebold*. See the Entomol. Zeitung zu Stettin, 1848, p. 292, 1850, p 329, also Beiträge zur Naturgeschichte der Mermithen, in *Siebold* and *Kölliker's* Zeitsch. für wissensch. Zool., v, 1853, p. 211.

made their escape. These freshly-escaped individuals were all sexless, but contained each a considerable *corpus adiposum*, at the expense of which their sexual parts were subsequently developed. These animals crawled about, and soon entered some damp earth, where they remained several months, during which time they were further developed, changed their skin, copulated and laid their eggs. The embryos hatched from these eggs, had the filamentoid form of the adults, and as Siebold conjectured that they intended to come to the surface for the sake of entering in their turn young insects, he procured quite young larvæ of this same insect and put them in an hour-glass together with the young Mermithes. In a few hours they had entered the body of these larvæ, two or three in each. Siebold had the precaution to make this point certain by carefully examining these larvæ previously and determining that their bodies were free of these parasites. After this, the same round of life is again passed. It would appear, then, that these animals pass their earlier (but not their embyonic) conditions of life whereby they attain their development—in fact a proper larval state—in the bodies of insects, and that their life as distinct sexed individuals is free and non-parasitic. Siebold found this species in very many genera of Lepidoptera, also in different species of Orthoptera, Coleoptera, and Diptera. We may mention that the common cricket as also some other Orthoptera, are frequent recipients of *Mermis*, and we have seen many specimens of this kind. Until Siebold's recent contributions we had supposed in common with other naturalists, that these Helminths merely hibernated in these insects, but this is now quite improbable.

So much for a brief reference to the mode of life of these animals; we will now turn and glance at some of the important histological points as wrought out by Meissner.

Cutaneous System.—Omitting the very full details given of the structure of the skin in these animals, its composition of three distinct layers, &c., we will allude only to the fact that *Chitine* enters likewise into its formation. This fact is important as corroborative of other observations. Chitine was formerly supposed to belong exclusively to the teguments of the Arthropoda, being particularly prominent in the skin of insects; but recent chemical analyses of the teguments of lower animals show that it occurs in nearly every class of the Invertebrata.* It can therefore no longer be regarded as having diagnostic characteristics for certain classes, but sustains relations to the external dermic skeleton of the Invertebrata generally, analogous to those of bone in the four classes of Vertebrata.

* Besides the present case we would refer to the following: *Grube*, *Müller's* Arch. 1848, p. 461, and *Wiegmann's* Arch. 1850, p. 253; *Schultze*, Beitr. zur Naturgesch. d. Turbellarien, p. 33; and *Leuckart* in *Siebold* and *Kölliker's* Zeitsch., 1851, p. 192, and *Wiegmann's* Arch. 1852, p. 22.

Muscular System.—This was found quite developed, and it is a singular fact that all the muscles have a longitudinal direction. Transverse muscles do not exist. But Meissner has indicated a histological feature of muscular tissue in these animals, which deserves notice. It is well known that striated muscular fibre is rather limited in its distribution among the Invertebrata. As stated in another place,* we have not observed it below the Articulata, and have regarded it as actually absent in the remaining classes —the Cephalopoda, Cephalophora, Acephala, Annelides, Turbellaria, Helminthes, Echinodermata, Acalephæ and Polypi. Now, we have hitherto supposed from observation that the fibre being the true embryological element of muscle, a further division into fibrillæ occurred only in the higher form of this fibre, the so-called *striated* muscle; in other words, that a fibrillated structure of muscular fibre was found only in the striated form. But Meissner describes the fibre of *Mermis* as readily capable of being split up into longitudinal fibrillæ of the most regular and delicate character, and yet neither these fibres nor fibrillæ are properly transversely striated. He remarks however, that an appearance like striation is sometimes observed by a wave-like contraction of the fibre.† Results of this character which the more careful research of the present day is developing, in studies of the lower animals especially, fully indicate that the subject of muscular tissue is not well understood as to its manifold variations of form; at least, after we have left the typical forms of the higher animals. Thus, as company for the present instance, I may mention that Leydig‡ found the muscles of the alimentary canal of *Artemia* among the Crustacea, composed of spindle-shaped instead of disc-like elements, so arranged, points and bases alternating, as to form a symmetrical fibrilla. In conclusion upon this system, we may remark that Meissner found here no sarcolemma, and no perimysium of the muscular layer.

Nervous System.—The researches of this investigator in this direction have particular interest, because this system has been generally denied to the Gordiacei, and if seen by previous observers it was only most unsatisfactory.§ But the histology of this system is quite as interesting.

Meissner found it so developed that he divides it into three portions: a central, a peripheric, and a splanchnic portion.

* This Journal, Jan. No., 1854, p. 89.

† We suspect it is this same wave-like aspect that has been often mistaken for striation in the muscles of some of the lowest animals, thereby leading to no little discrepancy among observers in their statements. See this Journal, Jan. No., 1854, p. 92, notes.

‡ *Leydig.* Ueber Artemia salina und Branchipus stagnalis, in *Siebold* and *Köllicker's* Zeitsch., iii, p. 280, Taf. viii, fig. 6.

§ *Berthold* and *Blanchard* both supposed they saw cords which might be nerves, but their observations were wholly unsatisfactory;—for references see *Siebold* and *Stannius'* Comp. Anat., Amer. ed., vol. i, § 104, note 5.

The *central portion* is divided into two parts, one at the cephalic, the other at the caudal extremity of the body. In the first, are two anterior and two posterior cephalic ganglia, and an œsophageal ring composed of a superior and an inferior ganglian united by lateral commissures. In the second part, situated in the tail, there are three fusiform ganglia, of like character but smaller than those of the head.

The *peripheric portion* consists of six filaments given off from the upper part of the anterior cephalic ganglia which go to as many papillæ on the head and probably organs of sense,—of two lateral cords arising from the superior œsophageal ganglion, which traverse the sides of the body, giving off filaments to the muscles, the skin, &c., and of some smaller twigs from the cephalic centres for the muscles of that region.

The *splanchnic portion* consists of two lateral trunks arising from the œsophageal ganglion, which soon meet and unite on the median line of the body, forming one cord which extends to the tail. From this cord are given off filaments to the organs of vegetative and reproductive life.

The three cords thus formed, having traversed the body, end each in one of the three ganglia above described. We can here allude to only one more point in the disposition of the nervous system; this is the final termination of the nerve-filament in muscle. According to our author, a twig enters the muscular fibre at right angles to the course of the latter, and upon its entrance divides into two twiglets, one of which runs with the fibre one way and the other the opposite, and is lost in the muscular tissue.*

The histology of this system in so minute animals as these, worked out by an observer so expert and faithful as Meissner, presents many note-worthy points.

The ganglia in question are composed exclusively of ganglion-cells or globules which appear to be the infundibuliform expansion of as many nerve fibres that compose the nervous cord connecting these ganglia with the general system. There are none of the so-called nerve-cells usually found in nervous centres—in fact these central masses rather resemble true ganglionic formations, excepting that they are terminal instead of on the course of a nervous cord. The description and figures, especially the latter, of Meissner are so good, as to leave no doubt that there is here a direct continuity of the nerve-fibre with the ganglionic vesicle.

In a former review† we alluded to some discrepancy on this point, and as this continuity had been observed by some, and yet

* As *Meissner* observes, a similar disposition is mentioned by *Doyère* (Ann. d. Sci. Nat., 1840, xiv, p. 346) in the muscles of the Tardigrada, and by *Quatrefages* (ibid, 1843, xix, p. 300) in the Eolidina, some Annelides and Rotatoria.

† This Journal, Sept. No., 1853, p. 253.

not seen by others who had searched carefully for it, we suggested that this direct connection, when present, might be an exceptional condition. But numerous researches since published, and especially the very complete memoir of Axmann,* represent this as a very common form of disposition of the elements of nervous centres in man and the mammalia. The subject is indeed somewhat obscure in a functional point of view, for what is the interpretation of this direct continuity of the vesicular with the tubular portion of this system? Certainly it is not the essential condition of function between the two, or all nerve fibres would terminate in this manner and there would be no ganglionic vesicles but those having this connection. But this, as is well known, is far from being the case. We leave the subject until another time. As to the structure of the peripheric nerves, our author describes them as having at first a distinct fibrillated structure as usual, but that this last gradually disappears and the nerve appears as a homogenous cord. But from our own investigations upon the terminal nerves of some insects, we suspect that this disappearance of the true fibrillæ may have been apparent and not real; for we have, in the cases referred to, thought that the like was true, but using higher powers with some reagents, the fibrillæ were seen. We think therefore that whatever may be made of termination of the nerve-fibre, the fibrilla structure is never lost.

Digestive Apparatus.—This structure, according to Meissner, presents so many peculiarities and is so widely different from any thing observed in other animals, that we almost relinquish any attempt to give even a brief description of it, without the aid of figures. In the first place, the alimentary canal has no anal or excretory passages, and therefore the food and assimilation must be such as to leave little or no so-called fæcal matter.

From the circular buccal orifice proceeds a semi-canal a short distance, when it passes into another structure. This semi-canal is the œsophagus. The structure into which it passes is a tube quite small at first but which soon expands and is filled with a finely granular spongy-like substance, and is alternately dilated from side to side into sacs. Through this laterally varicose tube the semi-canal of an œsophagus extends to its very end. Suppose then a tube with alternate lateral dilatations, filled with a spongy substance, and through which runs a semi-canal or half-tube like an œsophageal groove. Each of these dilatations has an inversion—a folding in of its internal membrane, producing an infundibuliform body in the dilatation itself. This body opens through a prolongation of the external membrane of the dilatation, which is continuous into a tube connecting with some adipose receptacles.

* *Axmann*, Beitr. z. mikroskop. Anat. u. Phys. d. Ganglien-Nervensystems des Menschen u. d. Wirbelthiere. Berlin, 1853.

To perhaps make the matter more clear, fancy the human alimentary canal without an anal opening, with alternate stomachs throughout its course, filled with a semi-solid granular substance; and that directly through it ran a half-tube; and that each stomach had a folding in of its internal lining forming a globular body, the neck of which passed off at right angles by a continuation of the peritoneum, into a tube which connected with receptacles of nutrition;—this would convey some idea of the most singular structure of the digestive canal of these animals.

The food passes along the semi-canal or groove, is gradually absorbed by the spongy substance filling the dilatation, thence passes into the invested body by endosmotic absorption and is then conveyed as assimilated material into the fat-receptacles which lie in the cavity of the body. These receptacles are storehouses of nutriment and are particularly enlarged and developed during the larval condition,—their contents being used for the formation of the sexual parts afterwards. Now as there is no vascular system in these animals, the dispersion of the nutrient material for the growth and substance of the various tissues must occur by permeation and endosmosis from the fat-bodies which extend over and between all the organs. This assimilation without any particular excretion is a remarkable fact; but it appears more conceivable when we bear in mind the economy of the animal. Its larval or parasitic state is like that of insects—merely preparatory for the ulterior changes of its full development. During this time its food is probably mostly pure fat which has only to be taken up and stowed away for material of the development of the reproductive organs. This last ensues during a quiescent state, and after the full discharge of the sexual functions, the animals probably die.

Genitalia.—Males.—The disparity in numbers of males and females was remarkably wide—our author having found only three males among several hundred specimens examined. He divides the internal organs into *testis*, *vas deferens*, *vesicula seminalis*, and *ductus ejaculatorius;* but these are all continuous, forming a cæcal tube stretching from the anterior portion of the body to the caudal extremity. The testis consists of the infundibuliform cæcal extremity of this tube and is lined with nucleated, epithelial (?) cells.

The external organs consist of two penises situated one on each side of the *Ductus ejaculatorius* in a sheath. They are composed of two somewhat curved half-canals disconnected when unprotruded with the internal organs; but when protracted, they form a more or less closed tube projecting beyond the external orifice of the duct.

Females.—Meissner divides the internal female organs, which are double, into five portions: *ovary*, *vitellus-organ*, *albumen-*

sac, *tuba*, and *uterus*. Their names indicate their respective functions and we can here enter into no description of their intimate structure.

In this connection should be noticed one point not a little remarkable, that is, a kind of hermaphroditism occurring in these animals.

Meissner found individuals which had perfectly well-formed internal female genital organs, but whose caudal extremity was wholly male. Thus, there were the penises, with their protractor and retractor muscles, their sheaths—in fact, all the external organs of the male, yet in these individuals no trace of internal male or of external female organs could be found. Moreover these organs present precisely the same characteristics as though in proper males and females, and had also a functional activity,—eggs being found in the ovaries, &c. But this anomaly was not ever found in the inverse sense, that is female external and male internal organs. Here then is presented the striking peculiarity of an animal having double systematically developed internal organs of one sex, and at the same time perfectly formed external organs of the other sex. This hermaphroditism, it will be seen, is like that of other animals only in name; for in these last the double sex is at the expense of the symmetry, one side being female and the other male, or it is due to modifications of analogous facts by different grades of development, thereby destroying generally the functional perfection and completeness of each or one of the forms of the sexual organs. But here we have a perfectly symmetrical female internally, with an equally symmetrical male externally, with no fusion of parts.

In regard to the development of the spermatic particles, our author's researches have been minute and quite complete. His results confirm the doctrines of Kölliker, Wagner, and our own: That is, parent sperm-cells in which are formed daughter-cells; in each of these last there is formed a spermatic particle. But Meissner is undecided if this formation occurs through a metamorphosis of the nucleus of the daughter-cell. Our own observations have led us fully to think that this nucleus is thus metamorphosed, as we have expressed in a former review.*

The development of the egg is quite note-worthy, as it shows, what we have before never clearly understood, viz: how botryoidal ovular masses are formed, and moreover carries out the beautiful analogy existing even to minute details, between the functions of the parent sperm-cell and the ovular cell. An ovular or egg-cell from the ovary is seen; it increases in size and its nucleus segments, several nuclei being formed. These nuclei approach the surface of this which we will now call the parent egg-cell; deverticula are given off from the cell-wall by a protrusion contain-

* This Journal, Nov., 1853, p. 393.

ing each a nucleus. These protrusions become constricted and at last appear as little, or daughter-cells, on the surface of the parent-cell. They now increase at the expense of this last, become pedunculated, and finally appear as larger pedunculated cells attached around a common, insignificant centre. These are the ova and form groups of variable number—Meissner having observed even twenty, though there are generally less. Thus formed, their peduncles break off and they pass from the ovary proper into the other sections of the genital tube.

There is one other point taken up in this connection by Meissner, and to which we briefly allude as it has been a subject of discussion on a former page.* We refer to the wonderful *Micropyle* of Keber, whereby it is alleged that the spermatic particles penetrate the interior of the egg and impregnate it. Meissner has seen nothing to justify the view that such a structure exists in the eggs of *Mermis* excepting the remains of the peduncle above mentioned, and this he is not sure of being hollow. Moreover even if it were hollow, it appears to us wholly different from the special structure insisted upon by Keber.

As to the embryonic development of *Mermis*, our author found nothing essentially different from what had been described by previous observers upon this order, (Grube, Leidy, &c.) There appears to occur no proper metamorphosis, and therefore the newly hatched embryos more or less closely resemble in form, &c., the adults.

In conclusion, we repeat what we said in the beginning, that this memoir is one of the most excellent of its kind we have ever seen, and the care, patience and fidelity displayed therein will ensure attention towards its author as one from whom much may be expected.

ART. XX.—*Correspondence of M. Jerome Nicklès, dated Paris, April* 30, 1854.

DEATH has recently made great havoc among the ranks of science in France. In the month of March alone, the Academy of Sciences lost two navigators, an astronomer, and a celebrated surgeon. Three of these eminent men died at an advanced age; the fourth, M. Mauvais, the astronomer, was but 45 years old, and came to a tragical end. They have been co-laborers in the common field, and we shall do a public service by giving some details of their life and labors.

Doctor Roux was born in 1780 at Auxerre. In 1795 his attainments in surgery were already so great that he was admitted as an assistant surgeon in the armies of the Republic. In 1797 he came to Paris and

* See a review on the doctrines of impregnation, in this Journal, Nov. No., 1853, p. 393.

gained the friendship of Bichat. In 1806 he entered as surgeon into the hospitals of Paris, and from that time he devoted himself with much distinction to the progress of his art. Endowed with great ardor and extraordinary activity, he was equally successful in scientific literature and in the amphitheater of surgery. He contributed much to the progress of this branch of the curative art, and was one of the first to give due prominence to the department of surgical anatomy. One of the most important processes brought forward by him, was the method of producing a union of the palate, (Staphyloraphy) an operation for the purpose of giving powers of speech to persons with a divided palate. The first person upon whom he performed this operation was an American physician, Dr. Stephenson, who after his cure, exhibited the operation to the Academy of Sciences.

A large number of new modes of surgical operation were contrived by M. Roux. He showed how to treat cases of lacerated perinæum, an affection before his time regarded as incurable. One of his most important specialties was the treatment of cataract, which he practised quite recently with as steady a hand as in youth. He preserved to the latest moment his characteristic vigor, and died suddenly in an apoplectic attack, distinguished as one of the greatest operators of the age.

Admiral Roussin.—The Admiral Albert Reine Roussin was born at Dijon, on the 21st of April, 1781. In 1793, at the age of twelve years, he was admitted as cabin boy to the floating battery "*République*," charged with the defense of Dunkirk. He commenced his career in the navy in the midst of engagements; and it was not until 1801 that he was able to devote himself to his studies. We will pass over the battles in which young Roussin bore a part, and which Capt. Duperrey has enumerated in detail upon the monument of the deceased. We will speak only of the services which M. Roussin has rendered to science and humanity. He made the hydrographical survey of the western coasts of Africa, rectifying the positions of the coast, and especially that of the shoal of Arguin, rendered famous by the melancholy shipwreck of the Medusa. During sixteen months on this commission, he explored about 400 leagues of coast, and published detailed charts, together with sailing directions, thereby rendering the navigation secure. In 1819, he explored the coast of Brazil, and furnished notes and directions relating to more than 900 leagues along the coast of eastern South America, thus forming "*le Pilote du Brésil*," a work which procured for him the distinction of a member of the Academy of Sciences. Admiral Roussin has added political honors to his scientific distinctions. He was Ambassador and afterwards Minister of Marine. He forced the entrance of the Tagus in 1831, and dispelled the notion then entertained, that the Tagus could not be attacked from the sea.

Admiral Roussin was a man of superior intellect, and of consummate skill in naval affairs, as expert in the art of producing as in the art of destroying.

Beautems Beaupré, the navigator, had not the double talent of Roussin. All his attention was devoted to the progress of navigation. He was born the 6th of August, 1766. He early evinced a decided taste

for naval life; and in 1791 he went with Admiral d'Entrecasteaux in the capacity of hydrographical engineer, in search of La Pérouse, on which voyage, he made a great step in the art of navigation, by substituting astronomical observations for the magnetic needle. He used the Reflecting Circle of Borda, and with much talent applied the problem relating to the angular capacity of a segment, which had been long familiar to geometricians, but had not been brought into practical use.

This long voyage was fertile in discoveries. To him is due the reconnoissance of the Kermadec Islands, the Archipelago of Santa Cruz, and of the Salomon Islands; of the coast of New Caledonia; of the island of Bougainville; of Boughton straits; nearly 300 leagues along the south coast of New Holland, and a small-boat survey of the bays of Van Diemens land, &c. &c.

These operations were finished just before the two frigates were captured by the Dutch. M. Beautems Beaupré was sent prisoner to the Cape of Good Hope, where he remained until 1796. Upon his return to France he resumed the continuation of the *Neptune de la Baltique*, which he had commenced before his departure. He afterwards published a survey of the Scheldt, and demonstrated that the seaport of Antwerp was accessible for vessels of the line of the largest class. Among the other labors of M. Beautems Beaupré, we mention only one,—namely, the hydrographical exploration of the southern and eastern coasts of France, a work which has commanded the admiration of all nautical men, and which won for its author from the English the distinguished title of the *Father of Hydrography*. The volume which records the results of this exploration received from its author the modest title of "Nouveau Pilote Francais." To him thanks are due, that the whole extent of the French coast may now be navigated with safety. In addition to these labors he collected the necessary materials for the publication of new charts of the French coasts, and brought together all the documents which might be useful hereafter in case of any new projects relative to navigation. This last labor comprises at present 527 volumes in 4to, and embraces all the documents necessary for preparing upon a gigantic scale, a plan of all the coast of France.

After the completion of these great labors in 1838, and their publication in 1843, the distinguished author aspired to a well merited repose, but he still continued to the end of his days to assist at the sittings of the Academy of Sciences, of which he had so long been one of the most assiduous members. He died in his 88th year, with the just renown of a good man.

Victor Mauvais, the astronomer, commenced life with the study of the law, but having an irresistible passion for the mathematical sciences, he renounced the duties of an advocate, and sought admission to the Observatory of Paris, to which he was nominated in 1836 by M. Arago. From that moment he gave himself exclusively to science. He discovered, successively, four comets, whose path through the heavens he watched with great assiduity during the whole time of their appearance. In the long series of observations which constitute the Archives of the Paris Observatory, the name of Mauvais is found in-

scribed upon almost every page. Of the 150,000 observations there recorded, over 30,000 are due to Mauvais.

In 1848 he was called by the department of Doubs to represent the people, and he remained in that capacity a member of the National Assembly until its dissolution. These duties did not interrupt his astronomical observations. He passed the day in parliamentary labors, and the night in observing the heavens. He had undertaken a serious labor, in the absolute determination of the position of the fundamental stars. Struck by the discrepancy which had been remarked between the right ascension of certain stars, he conceived the idea of a series of observations with the meridian circle. He had chosen two groups each of twenty stars, succeeding each other on the meridian, after an interval of twelve hours, and had observed their passage at intervals of six months, proposing to compare them afterwards with the sun in order to deduce the position of the equinoctial points. This important labor remains unfinished.

Incessant fatigues and night watchings had broken down the health of Mauvais. He suffered much from a disease of the intestines. The death of Arago and the unexpected separation of the Bureau of Longitudes from the Observatory affected him deeply. Disapproving the course taken in this case, he left the Observatory with MM. Mathieu and Laugier, son-in-law and nephew of Arago, and determined to suspend for some time his researches. Effort was made to induce him to resume his position in the Observatory; but being the friend of Laugier he preferred to share his fate. The care and anxiety which sprung from these circumstances sadly affected the health of Mauvais. From the stomach the malady went to his head, and in a paroxysm of burning fever he took his life by the discharge of a gun.

Mauvais was born at Maiche, a little village of the department of Doubs, on the 7th of March, 1809. He died the 23d of last March, and was consequently 45 years old.

The Paris Observatory.—Before the death of Arago the director of the Observatory was chosen annually. In consequence of the new measures, the Observatory will hereafter have a permanent director, and the Bureau of Longitudes will not have a voice in this nomination. Owing to these changes and to many others made in the regulations, some of the astronomers (MM. Mathieu, Mauvais and Laugier,) gave in their resignations and left the Observatory. The corps of the observers has thus been considerably changed. According to the new regulations it is to comprise, 1, A Director, 2, Four Astronomers, 3, A variable number of adjunct astronomers, pupils, and computers proportioned to the demands of the service. The director is M. Leverrier; MM. Faye and Yvon Villarceau have been named astronomers; and MM. Babinet and Goujon adjunct astronomers. A third adjunct has been lately appointed, M. Chacornac, a pupil in the Marseilles Observatory, discoverer of *Massilia* and *Phocéa*, and also author of a valuable chart of the Ecliptic. M. Chacornac entered on his duties on the afternoon of the 2d of March, and on the night of the 3d–4th of March he discovered, near the star *Spica Virginis*, a small planet which he had found at Marseilles on the night of the 4th of February, and marked upon one of the charts of the Ecliptic. The same planet was observed

on the second of March, by Mr. Marth, at the Observatory of Mr. Bishop, in London, and named *Amphitrite.*

Electricity.—Apropos to the notice which we have given in the No. for March, p. 265, on the passage of two unlike electrical currents over the same wire, the Abbé Moigno states the following fact mentioned in his treatise on the electrical telegraph and established by MM. Breguet and Gounelle, the 7th of April 1847. These experimenters attempted to send at the same moment telegraphic signals in inverse order, over the line from Paris to Rouen. The signals were reproduced on either side with the most perfect exactness. This experiment was many times repeated, and before a Commission of the Chamber of Deputies, and the circuit was always complete. It may be objected to this fact that the signals were not exchanged at the same indivisible instant, and that it only proves that the currents were of unequal intensity. Notwithstanding the adverse opinion of many physicists, it does not appear to us impossible that two electrical currents may circulate over a conducting wire at the same time, the proof of which will be found in the experiment cited in this Journal for March, p. 266.

The decomposition of water, the process of which is not always as simple as it would seem to be from theory, has received new light through a recent discussion. When care is taken thoroughly to refrigerate the acidulated water, which is the subject of experiment, it is remarked that the volume of the gases is no longer in the relation of 1O : 2H, as theory requires; but the hydrogen is apparently in excess, owing to a notable portion of oxygen being retained by the water. This fact has been simultaneously and separately determined by MM. Jamin, Leblanc, and Sozet.

M. Ch. d'Almeida, Professor of Chemistry in the Lyceum of Henry IV, has investigated the question *whether the deposit of copper found in a solution of the sulphate of that metal when subjected to electrolysis is the product of electrolytic decomposition, or of the decomposition of the copper salt by nascent hydrogen?* By very ingenious experiments, the details of which cannot be given here, M. d'Almeida has proved that in a neutral solution, the neutrality of which is carefully preserved during the operation, the metal deposited at the negative pole is essentially derived from the direct decomposition of the salt. In acid solutions, on the contrary, the reduction is the result of nascent hydrogen. These results lead to the important practical conclusion, that in the electro-chemical decomposition of a metallic salt by the battery, the solutions should be preserved as neutral as possible. This observation is specially applicable in the study of electro-chemical equivalents.

M. Gaugain has studied some of the forms of batteries with reference to the causes which produce variation in the electro-motive force. In comparing the several couples of a thermo-electric battery, he detected between them a variation equal to 12 or 14 per cent. of the mean electric force. He ascribes this variation to a difference in the texture of the Bismuth, which is more or less crystalline according as the metal has been cooled more or less rapidly. These comparisons were made by means of a galvanometer interposed between the couples placed in opposite relations, so that each cup of the galvanometer receives the + pole of one couple and the − pole of the other.

M. Gaugain has also compared the battery of Wheatstone with that of Daniell, adopting the method of the opposition of piles. According to this observer, in Wheatstone's battery, the cause which has the most influence upon the electro-motive force is the diaphragm. This cause does not affect the electric force of Daniell's battery, which like other batteries employing two fluids, is modified by the phenomena of chemical affinity. The author has observed that the electro-motive force of Daniell's battery is diminished by the agitation of the solution in which the zinc plate is placed.

Various Memoirs.—Among the numerous communications which have been made to the Academy, there are new facts relating to the absorption or non-absorption of the nitrogen of the atmosphere by plants. M. Boussingault rejects the theory of absorption, which his numerous experiments have failed to verify, and M. Dumas agrees with him in opinion. But a young chemist has appeared, who sustains with courage the opposite view, and appeals to many facts and experiments in his support. On which side is the truth? The question is too nearly poised, soon to be solved. The debate has produced a sensation equalled only by that of another memoir—one on the preparation of Aluminium, by M. H. St. Claire Deville. Deville, who is skillful in applying heat above all French chemists, has contrived a method of preparing aluminium economically, similar to the process for obtaining potassium and sodium, using a very high temperature. We propose in another communication to give views of the lamp and forge which Deville uses in his laboratory for fusing the most refractory bodies. The note of Deville has brought out a number of communications on the subject of the economical preparation of Aluminium, none of which have yet been verified, and we wait for positive facts before touching upon them.

While Deville has been occupying himself with Aluminium, his assistant, M. Debray, has been studying Glucinum, which metal (as well as Aluminium) M. Wöhler was the first to obtain separate, although in an impure state, if we may judge from the properties of this metal mentioned by M. Debray. According to this chemist, Glucinum is lighter than Aluminium; its specific gravity is 2·1. It looks like zinc, but is less fusible, non-volatile, unalterable at the ordinary temperature and oxydizes on the surface at the blowpipe temperature without affording the phenomena of ignition produced under the same circumstances by zinc and iron. Concentrated nitric acid attacks it only when hot, and diluted acid under no circumstances. Chlorhydric and sulphuric acids, even diluted, dissolve it, disengaging hydrogen. Potassa dissolves it even when cold; ammonia is without action.

Table Turnings.—Much interest has been excited by a paper of M. Chevreul's to the Academy of Sciences, taken from the introduction of a work now in press, in which he treats of the phenomena of table-turnings. This distinguished chemist does not confine himself to this subject alone, but connects with it, the "Exploring Pendulum," and "Divining Rod," and he endeavors to reduce these phenomena to certain rational facts. In 1812, he noted the phenomena of the pendulum in a letter addressed to Ampère, and showed that the pendulum movement was produced only when the eye of the experimenter was fixed

on the instrument; and he endeavored to prove thereby that the motion was due to a play of the muscles. The work of M. Chevreul should properly be read and submitted to a commission; but some members of the Academy have objected to the consideration of a subject connected to such an extent with superstition. M. Chevreul believes that the question may be treated without going out of the domain of true science, agreeing with Arago and Faraday, and regards it not unworthy of a man of science to occupy himself with any demonstrated facts in order to search out their relation to other facts.

Works of Arago.—The works of Arago have begun to appear, published by Gide and Baudry. The first volume is on sale. It opens worthily the remarkable series of papers which will appear successively in the 12 volumes to be issued, as the posthumous works of a man who like Franklin was distinguished both in the State and in Science. This two-fold character of the man will appear throughout the published pages. The first article is entitled "The History of my Youth." It is in fact a romance, in which are interwoven the adventures of Arago in Spain, and also piquant details relating to many of the principal scientific subjects of the epoch. It contains also his Eulogies on Fresnel, Volta, Young, Fourier, Watt, and Carnot. Each of these eulogies is at the same time a complete treatise on one or several branches of science, illustrated by the life of the person of whom it treats. Thus under that of Fresnel, we find the most recondite questions in optics treated with a perspicuity and charm which render it attractive and intelligible to persons in the least familiar with this branch of study; as for instance, *Double Refraction*, *Polarisation*, *Diffraction*. In the eulogy of Watt, the *Steam Engine* is the subject; in that of Volta, it is the *Galvanic pile;* in that of Fourier, it is *Heat;* that of Carnot, it is mechanics in general, and military engineering; in that of Young, the subject of the interference of light, and Egyptian hieroglyphics. There are also other points touched upon, which give the eulogies a historic interest; as with Carnot, who organized the victorious republican armies, and with Fourier, the friend of Kleber in Egypt, who took a part too direct to be passed unnoticed, in the great events at the close of the last century and commencement of this. No one better than Arago appreciated these great characters. He has depicted with the hand of a master, the services they rendered to the cause of humanity, their discoveries in science, and their virtues.

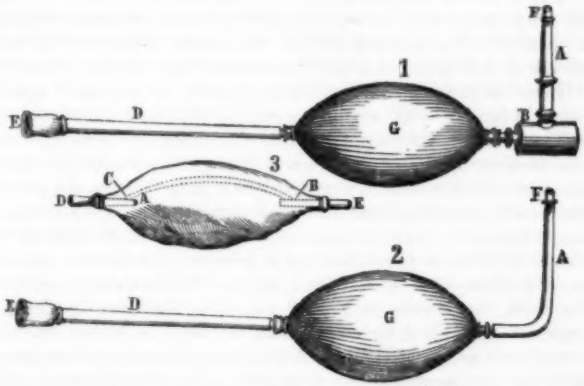
The volume is preceded by an introduction by M. Alexander von Humboldt, whose friendship for Arago dates back nearly half a century.

Poisonous effects of Carbonic Oxyd.—At the World's Fair at London, there were exhibited certain samples of iron and steel, of peculiar property, prepared by means of spongy iron, which was obtained by reducing the ore by using a mixture of hydrogen and carbonic oxyd produced by the action of steam on incandescent charcoal. The iron thus prepared, is very oxydizable, and decomposes water with an energy far exceeding ordinary iron. The author of the process, M. Chenot, proposes to use this spongy iron in obtaining aluminium, and he promises even to prepare this metal at the order of the Academy, by the kilogram for industrial purposes. We state this by way of introduction, in order to justify the observation communicated by this same

chemist, relating to the poisonous effects of carbonic oxyd. Having been for many years occupied with this gas, he has proved upon himself its deleterious qualities; and he announces that he is at this very time suffering from a new poisoning with this gas. Mixed with atmospheric air, the gas is little dangerous, but in the pure state it is a violent poison. The person taking it, says the author, falls as if struck by lightning; his eyes roll up in their sockets, his members become stiffened, the skin discolored, the veins inflated and looking blackish under the skin; the sensibility becomes extreme, and life is exalted in activity: the brain seems to be compressed, and terrible pains are felt in the thorax. The lassitude continues general for several days; sleep becomes heavy and troubled, and there are severe cramps in the legs and toes. These effects are continued for months; the person appears sad and dejected; any noise produces a nervous shock like an electric discharge.

The antidote used by M. Chenot is gum or marsh-mallow water; bathing gives much relief. These remedies alleviate but do not remedy the effects of the poison. For several weeks, now, since M. Chenot inhaled this gas, through the breaking of a manometer, he has suffered from an insurmountable feebleness and loathing; and the least touch, even his own, produces on him severe irritation.

Blowpipe with a continued Blast.—The blowpipe here figured has the merit of enabling the operator to keep up a continued blast, without the



practise required for the ordinary blowpipe, and without fatigue. M. de Luca observes that it is only necessary to blow as in an ordinary tube. The peculiarity of the blowpipe consists in the addition of a bag of vulcanised india rubber, G, having within a valve A (fig. 3), which opens from without inward, and closes from within outward, and is placed at the extremity of the mouth-tube. The valve admits the air, but prevents it from returning. The india rubber bag, by its elasticity, throws a stream out regularly by the aperture; and it serves also in place of the ordinary condenser. Figure 1 is the blowpipe with the india rubber bag; in figure 2, the cylindrical recipient is removed.

M. de Luca is a refugee Neapolitan, and one of the directors of the *Ateneo Italico*. The application which he has here made of the vulcanised india rubber bag appears to be copied from the "Cornemuse," a picturesque musical instrument much used among the Neapolitan herdsmen.

Use of Oxygen in Asphyxia.—Two physicians, MM. Faize and Genetti, who are experimenting on the effects of gaseous bodies on the animal economy, have observed that oxygen restores life to animals in which it has been nearly extinguished, as it restores brilliancy to a burning body which is nearly out. They have operated in various cases, such as asphyxia by chloroform, carbonic acid gas, and even strangulation. When life appeared to be extinct, so that the beating of the pulse and movement of the chest were hardly sensible, they have injected oxygen into the lungs and almost immediately the effect was apparent and there was a restoration to life. In some comparative experiments, made under like conditions, they have shown that the atmospheric air was almost always without effect, and in no case can its action be compared to that of oxygen which is all-powerful and instantaneous.

Local Anesthesis.—The anesthetic experiments spoken of in my last communication, although they have not led to a successful result, still have suggested an application which appears to resolve the problem in a different manner. It is now attempted to produce local anesthesis by *cold*. The mode of operation is very simple. The ether is applied, drop by drop, to the part to be subjected to the operation, and evaporation is promoted by a current of air. The ether is believed to act only as a means of refrigeration; but however this be, the process employed by M. Richet at the Hotel Dieu in the removal of a tumor appears to have been attended with success, and it is reported with details in the medical journals. After cooling with the ether for four minutes, the surgeon, perceiving that the part was insensible, plunged in his knife and made an incision near 5 centimeters in length; and the patient felt no pain although awake, and was hardly aware of the operation.

Photography and Stereoscopy.—At one of the late sessions of the Academy, M. Claude exhibited some stereoscopic views representing groups of persons with remarkable effect. He had calculated the distance so well, that on the instant of applying the eyes to the glasses, the single image with three dimensions was seen, and not two images.

At another session, M. Elie de Beaumont, Perpetual Secretary, presented to the Academy, on the part of M. Frederic Martens, engraver and photographer at Paris, a number of photographs on paper, representing the Swiss glaciers and mountains, as the glaciers of Monte Rosa, Mt. Cervin, etc. This last mountain has the form of a pyramid, and, as the Swiss say, resembles a bayonet. The views represent this pyramid as obtuse and eroded, seemingly false if common observation is correct, but in fact right, the error being that of the observer, to whom, as has been often remarked, vertical objects, such as mountains and distant edifices, always appear steeper and more elevated or pointed than they really are.

Bath for bringing out Photographs.—Sulphate of iron has been often recommended for bringing out proofs on taking them from the camera.

The use of this sulphate excludes that of the hyposulphite of soda for the solution of the iodid of silver not modified by the light; in fact, the sulphate of iron should always be acidulated; and consequently it decomposes this hyposulphite producing a deposit of sulphur, which forms with the silver a sulphuret, especially injurious in the production of direct positive proofs. This effect will not take place if the proof has been carefully washed after leaving the bath of sulphate of iron; still the decomposition of the hyposulphite goes on spontaneously, and if the precaution is not taken of filtering the solution of hyposulphite, the same accidents occur.

To avoid this difficulty, M. Adolph Martin dissolves the iodid of silver that has been acted on by the light by using a solution of cyanid of silver in cyanid of potassium. Cyanid of potassium alone does not produce the same result; for in the presence of sulphate of iron, this simple cyanid gives origin to the ferro-cyanid of potassium, which affords Prussian blue with the least trace of sulphate of iron in excess, and tinges the proofs of an intense blue color. If on the contrary the cyanid of silver dissolved in the cyanid of potassium is used, there is produced indeed a little ferro-cyanid of potassium which in the presence of the salts of silver is decomposed, causing a deposit of hydrated peroxyd of iron of a yellow color; but it adheres but slightly to the proof, and if the quantity of hydrate is not large, a simple washing for a while in ordinary water will remove it.

A new red dye for dyeing wool.—On treating uric acid with nitric acid and then with ammonia, Proust obtained, at the beginning of this century a red substance which he called purpurate of ammonia. MM. Wöhler and Liebig have since studied this substance and separated a compound of a fine red color represented by the formula $C^{12}N^5H^6O^8$, which they call *murexid*. This material, which is easily prepared from alloxane and ammonia, has been applied to dyeing wool, for which it furnishes a red color richer than that of cochineal. The author of this process is M. Albert Schlumberger of Mulhouse (Haut-Rhin). His experiments have been verified by a commission from the Industrial Society of that town.

The red of murexid fixes itself on the wool without a mordant. After imbibing the alloxane, a bit of wool drying exposed then to ammoniacal vapors and afterward to the heat of a steam drum or heated iron, the red color is seen to be immediately developed. It is indispensable that the ammonia should be applied before the heat. The color is not produced if the specimen impregnated with alloxane has been heated; water removes this last, while it is wholly without action on murexid.

Although this color requires no mordant, M. Schlumberger has however found that a mordant may be useful. That which he prefers is a bath consisting of equal parts of bichlorid of tin and oxalic acid, the whole forming with water a solution marking 1° Beaumé. The mordants made with protochlorid of tin give indifferent results.

Under the action of the sun's rays, the Commission found the red of murexid to be more stable than that of cochineal, and they do not hesitate to recommend the use of it in dyeing gobelins in preference to cochineal, although the new red is just now dearer than the old, since

uric acid or alloxane are now known only in the laboratories. The price will be cheapened when it is made a branch of industry, and it is certain that guano will here find a new demand.

The red of murexid resists the action of alcohol, ether, and the acetic and oxalic acids. Muriatic, nitric and sulphuric acids destroy it; but if the destruction is not complete, the color may be restored by means of ammonia. Caustic alkalies destroy it rapidly. Reducing substances, such as protochlorid of tin, sulphate of iron, cause it to disappear; but the color may be restored by means of ammonia.

Cotton, whether with a mordant or not, whether animalized (Broquette's process) or mixed with wool, is not dyed with murexid. Impressed with the alloxane and then treated with hot iron, cotton is colored it is true of a rose tint, and the color is deepened with ammonia; but the color does not stand washing, water causing it wholly to disappear.

Silk does not take the amaranth color of murexid; it becomes yellowish rose. M. Schlumberger recognizes in this property a means of distinguishing cotton, silk, and wool.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Thermic Researches on Hydroelectric Currents.*—Under this title Favre has published the first part of an investigation which promises to throw much light upon a very obscure part of the theory of the voltaic pile. In the present memoir the author considers the calorific effects developed in the galvanic circuit in their relations to the chemical action which gives rise to the current, and to the electro-chemical decompositions which the current may produce. The results obtained are as follows.

(1.) The chemical actions generated by the elements in activity are the exclusive source of the calorific effects produced by the battery.

(2.) All the chemical actions which take place in the voltaic couple concur simultaneously in the production of the current.

(3.) The disengagement of heat produced by the passage of voltaic electricity through metallic conductors is rigorously complementary to the heat confined in the elements of the battery, to form a sum equal to the total heat corresponding simply to the chemical actions independent of all electricity transmitted.

(4.) The chemical decompositions which the passage of the electricity through the circuit may effect, always bring into play quantities of heat the same as those which accompany chemical decompositions effected by other influences. The heat brought into play in the act of these decompositions results always from a draft made upon the total heat disengaged by chemical actions in the voltaic apparatus.—*Ann. de Chimie et de Physique*, xl, 293, *March*, 1854.

2. *On the double refraction temporarily produced in isotropic bodies, and on the relation between mechanical and optical elasticity.*—Werth-

EIM has communicated an elaborate memoir upon these important subjects; we must however refer to the original paper for the details of the experiments and content ourselves with stating the results which, in the author's own words, are the following.

(1.) The double refraction artificially produced, either by traction or by compression, is, for the same substance, proportional to the linear changes which the mechanical force produces in the direction of the principal axes, and consequently is also proportional to the changes of volume of the body.

(2.) The temporary lengthenings and shortenings which a given weight produces, according as it acts by traction or by compression, are neither rigorously equal to each other, nor exactly proportional to these weights, so long as these are relatively small; but these differences disappear as soon as the weights become somewhat considerable, and long before those which produce the first sensible permanent alterations.

If we lay off the weights on the axis of abscissas and the corresponding lengthenings and shortenings upon the axis of ordinates, the first below and the second above this axis, we obtain two similar, if not equal, curves, the first of which is convex and the second concave toward the axis of abscissas. These curves insensibly become straight and for linear charges which are scarcely measurable by ordinary means, become undistinguishable from a straight line which represents the proportionality between the charges and their temporary effects. These facts are confirmed by direct experiments made by different observers, experiments the results of which were only too uncertain to clearly exhibit the truth of the law; this confirmation results especially from the experiments of Mr. Hodgkinson when we calculate them so as only to take the temporary effects into consideration, and when we pay attention to the causes of errors which influence all direct experiments made by compression.

(3.) The optic axes correspond with the mechanical axes in all truly isotropic bodies, whether they have been endowed with negative double refraction by pressure or with positive double refraction by traction. The double refraction or the difference of path of two rays, ordinary and extraordinary, may be determined very accurately by means of the dull complementary tints which the two images of a white ray take, when the principal sections of the polarizing Nicols prism and the doubly refracting analyzing prism make an angle of 45° with the direction of the force which is applied to the body placed between these two prisms. In these two cases the colors ascend with the changes following exactly the series of the colored rings of Newton; for measurements, however, we can scarcely make use of these colors of more than the first seven half rings: the colors of the transmitted rings are those of the ordinary image while the tints of the reflected rings correspond to the extraordinary image.

(4.) Making no account of the small differences which have just been pointed out, the temporary double refraction is independant of the height and length of the piece, proportional to the weight applied and to the doubly refracting power of the substance, and reciprocally proportional to its breadth and to its coefficient of mechanical elasticity.

(5.) The doubly refracting power of an isotropic substance which has become temporarily doubly refracting, cannot be expressed but by the difference between its ordinary and its extraordinary index; this difference changes its sign only according as we apply pressure or traction, which would not be the case if we wished to express the doubly refracting power by a function of the two indices other than the difference of their first powers.

(6.) The dispersion of double refraction is insensible for substances which have been submitted to experiment.

(7.) Glasses which had been submitted to the operation of compression while in a pasty state, ceased to be optically homogeneous bodies, and this alteration, entirely distinct from what is called tempering, did not always disappear by annealing.

(8.) The doubly refracting power is not the same for different isotropic substances; no connection can be established between this power and the ordinary index of refraction or even the density.

(9.) By analogy with the ordinary or mechanical coefficient of elasticity E, we call coefficient of optical elasticity C the ratio between the charge applied to the unit of surface and the double refraction which it produces; we have then the simple equation,

$$I_o - I_e = \frac{E}{C}$$

which serves to determine the doubly refracting power

$$p = \pm (I_o - I_e).$$

(10.) The value of the doubly refracting power being once known for a substance, we may use the phenomena of double refraction to determine any one of the quantities which enter into the equation

$$\pm P (I_o - I_e) = d \,.\, E \,.\, La,$$

where P is the charge, I_o and I_e are the indices for the ordinary and extraordinary ray, d is the difference of path, and La the breadth of piece employed.

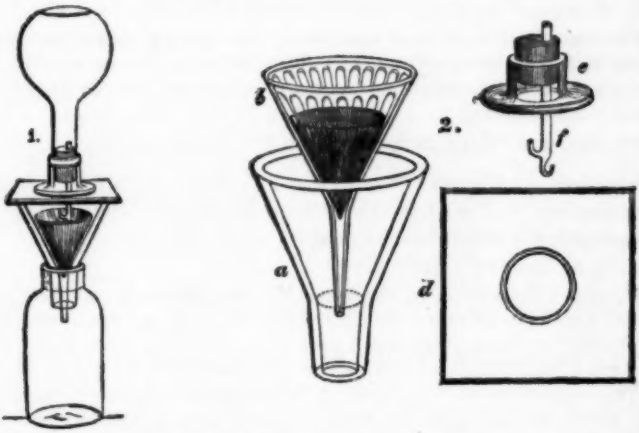
(11.) The most important of these applications consists in the determination of the force P, whatever be its magnitude and mode of action. The chromatic dynamometer gives immediately, and without the employment of any coefficient of correction, the effective pressure which is exercised by a screw press, fly-wheel, hydraulic press, lever, &c. it will serve to make known for all these machines the ratio between the useful and the theoretical effect, to graduate ordinary manometers accurately, and even to measure living forces.

(12.) The same formula would serve to determine the coefficient of mechanical elasticity if we had a direct method of finding the extraordinary index Ie; but in the mean time it has permitted me to establish the optical coefficient of the diamond, and to fix certain limits between which its mechanical coefficient is comprised.

(13.) The difference of path d being independent of the length of the undulation λ, if the ratio $\frac{d}{\lambda}$ is to remain the same for the different values of λ, P must vary proportionally to λ; which furnishes an easy method of determining the lengths of undulations, and of deciding whether a given ray is homogeneous, or what are the different simple rays of which it is composed.

(14.) The phenomena of magnetic rotation disappear in all bodies in proportion as they cease to be mechanically homogeneous and optically isotropic; it is to be remarked that among bodies which are naturally doubly refracting or which are rendered so by the employment of a mechanical force, those which have the most energetic powers of rotation are those which are at the same time endowed with the feeblest doubly refracting powers.—*Ann. de Chimie et de Physique*, xl, 156, *February*, 1854. W. G.

3. *On a new Filtering Apparatus;* by Prof. J. P. Cooke.—It is frequently important in chemical analysis to conduct the process of filtration either in vacuo or in a neutral gas, especially in an atmosphere free from carbonic acid. In order to overcome certain difficulties, I have been led to contrive an apparatus for this purpose, which, as I believe, is superior to all others now in use, both on account of its simplicity and its cheapness. The complete apparatus is represented in Fig. 1, and some of its parts enlarged appear in Fig. 2. It consists of a wide-mouthed



glass bottle, into the neck of which is firmly ground with emery a funnel (*a*, fig. 2) having a short but large spout. These are made sufficiently thick to resist the atmospheric pressure, and the rim of the funnel is ground so that the apparatus may be closed air-tight by means of a g ass plate. Within the outer funnel the common filtering funnel is placed resting loosely against its side so as to allow a free passage of air.

In order to wash a precipitate, or to produce a vacuum in the interior of the apparatus, a glass plate with a hole an inch or more in diameter drilled through its centre (*d*, fig. 2) is substituted for the covering plate. Through this passes the tube of a washing bottle (*f*, fig. 2) The washing bottle is made in the ordinary way except that it is fitted with a cork, which projects about an inch above the neck. This upper end of the cork fits the neck of a glass plate ground on the under side as is represented at *e*, fig. 2. The plate is about three inches in diameter, and when resting on the plate *d*, (see fig. 1) covers the opening completely and permits sufficient lateral motion to bring the stream of water on different parts of the precipitate. A vacuum is readily ob-

tained by connecting the apparatus with an air pump by means of a flexible tube having a brass plate at the end sufficiently large to cover the opening in the plate *d*, and by an easy manipulation the interior may afterwards be filled with hydrogen, or any other gas.

Numerous processes in which this apparatus may be advantageously applied will suggest themselves to the chemist. I have found it very useful in washing precipitates with volatile liquids, (as in the separation of fats) in preparing many metallic protoxyds, in separating the alkaline earths from alumina and sesquioxyd of iron, &c. Moreover it will be found useful in protecting both precipitate and filtrate from the dust and fumes of a laboratory in many cases even when exclusion of air is not essential. The apparatus is manufactured by the New England Glass Co., and sold by Mr. J. M. Wightman, of Boston, at a price not exceeding that of a filtering stand with brass rings.

II. Mineralogy.

Chemical Contributions to Mineralogy; by James D. Dana.

Chlorite Section of Hydrous Silicates.—Among *Anhydrous* Silicates, there is a group of species (which the writer has called the Andalusite Section), in which the oxygen of the bases exceeds that of the silica. It includes

1. Staurotide $\dot{R}^3\ddot{S}i^{\frac{4}{3}}$, Andalusite $\dot{R}^3\ddot{S}i^{\frac{4}{3}}$, Topaz $\dot{R}^3\ddot{S}i^{\frac{2}{3}}$;—Trimetric and homœomorphous.
2. Kyanite $\dot{R}^3\ddot{S}i^{\frac{4}{3}}$, Sillimanite $\dot{R}^3\ddot{S}i^{\frac{4}{3}}$; also $\dot{R}^3\ddot{S}i^{\frac{4}{3}}$, $\dot{R}^3\ddot{S}i^{\frac{5}{3}}$, $\dot{R}^3\ddot{S}i$?—Triclinic.
3. Euclase $\ddot{R}\ddot{S}i^{\frac{4}{3}}$, Sphene $(\ddot{T}i+\dot{C}a)\ddot{S}i^{\frac{4}{3}}=(RO^2+RO)\ddot{S}i^{\frac{4}{3}}=\ddot{R}\ddot{S}i^{\frac{4}{3}}$;—Monoclinic.
4. Tourmaline $(\dot{R}^3, \ddot{R}, \dot{B})\ddot{S}i^{\frac{4}{3}}$;—Rhombohedral.
5. Gehlenite $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{4}{3}}$;—Dimetric.

Parallel with this Group, there are *Hydrous* Silicates, and they constitute what may be called the *Chlorite Section.* In a few among them, as Euphyllite, Hisingerite, and Pyrosclerite (in part), there is the ratio 1 : 1; but in all the others, the ratios are either 1 : $\frac{3}{4}$, 1 : $\frac{2}{3}$ or 1 : $\frac{1}{2}$.

The oxygen ratios of the species, for the protoxyds, peroxyds, silica, and water, according to the most recent analyses, together with the accepted formulas, are as follows:

	$\dot{R}$	$\ddot{R}$	$\ddot{S}i$	$\dot{H}$	
Hisingerite (A), - - - -	1	2	3	2 (or 3)	$\dot{F}e^3\ddot{S}i+2\ddot{F}e\ddot{S}i+6$(or 9)$\dot{H}$
" (B), - - - -	3	1	4	3	$3\dot{F}e^3\ddot{S}i+\ddot{F}e\ddot{S}i+9\dot{H}$
Thuringite, - - - - -	2	3	3	2	$2\dot{R}^2\ddot{S}i+\ddot{R}^2\ddot{S}i+6\dot{H}$
Pyrosclerite (A), - - -	4	2	6	4	$2\dot{R}^3\ddot{S}i+\ddot{R}\ddot{S}i+6\dot{H}$
" (B), - - -	6	4	$7\frac{1}{2}$	5	
Euphyllite, - - - - -	1	8	9	2	
Margarite, - - - - -	1	6	4	1	$\dot{R}^3\ddot{S}i+3\dot{A}l^2\ddot{S}i+3\dot{H}$
Clinochlore, } - - - - -	5	3	6	4	$\dot{R}^3\ddot{S}i+\ddot{R}\ddot{S}i+2\dot{M}g\dot{H}^2$
Chlorite, }					
Delessite, - - - - -	2	2	3	2	
Ripidolite, - - - - -	3	3	4	3	$3\dot{R}^3\ddot{S}i+\ddot{R}^2\ddot{S}i+9\dot{H}$
Aphrosiderite, - - - -	3	3	4	2	
Chloritoid (A), - - - -	1	2	2	1	$\dot{R}^3\ddot{S}i+\dot{A}l^3\ddot{S}i+3\dot{H}$
" (B), - - - -	1	3	2	1	
Cronstedite, - - - - -	1	1	1	1	
Sideroschisolite, - - -	0	2	1	1	
Clintonite,* - - - - -	3	5	2	1	

* The analyses of this species by Meitzendorff give the oxygen ratio for $\dot{R}, \ddot{R}, \ddot{S}i, \dot{H}$, 12·22 : 20·52 : 8·64 : 3·85, which equals quite closely 3 : 5 : 2 : 1.

It will be observed that in several of the above formulas the two silicates of the formula differ widely in oxygen ratio; thus, in Ripidolite, the protoxyd silicate has the ratio 1 : 1; while the peroxyd has the ratio 3 : 1 = $\dot{R}\ddot{S}i^{\frac{1}{2}}$, a very doubtful possibility under any circumstances.

Viewing these same ratios in a different manner, that is, taking the ratio between the sum of the oxygen of the protoxyds and peroxyds and that of the silica, more simple results are obtained, and the parallelism with the Andalusite Section of Silicates is brought out. We thus make out four groups, as follows:

1. General Formula $(\dot{R}^3, \ddot{R})\ddot{S}i + Aq.$
2. " " $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{3}{2}} + Aq.$
3. " " $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{4}{3}} + Aq.$
4. " " $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{1}{2}} + Aq.$

In *Clintonite*, whose ratio corresponds to $3\dot{R}^3$, $5\ddot{A}l$, $2\ddot{S}i$, $3\dot{H}$, if $2\ddot{A}l$ replace silica, the species has the general formula $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{4}{3}} + Aq$, like Chloritoid (A).

Again, in *Thuringite*, if one third of the alumina replace silica, the formula may be $(\dot{R}^3, \ddot{R})(\ddot{S}i, \ddot{A}l)$ analogous to that of Hisingerite.

Writing out the proportion of $\dot{R}^3$ to $\ddot{R}$, these formulas become:

Group I. *General Formula* $(\dot{R}^3, \ddot{R})\ddot{S}i + Aq.$

Hisingerite (A),	$\dot{F}e^3\ddot{S}i + 2\ddot{F}e\ddot{S}i + 9\dot{H}$	$= (\frac{1}{2}\dot{F}e^3 + \frac{1}{2}\ddot{F}e)\ddot{S}i + 3\dot{H}$
" (B),	$3\dot{F}e^3\ddot{S}i + \ddot{F}e\ddot{S}i + 9\dot{H}$	$= (\frac{3}{4}\dot{F}e^3 + \frac{1}{4}\ddot{F}e)\ddot{S}i + 2\frac{1}{4}\dot{H}$
Thuringite,	$\dot{F}e^3\ddot{S}i + \ddot{R}(\ddot{S}i, \ddot{A}l) + 3\dot{H}$	$= (\frac{1}{2}\dot{F}e^3 + \frac{1}{2}\ddot{R})(\ddot{S}i, \ddot{A}l) + 1\frac{1}{2}\dot{H}$
Pyrosclerite (A),*	$2\dot{R}^3\ddot{S}i + \ddot{A}l\ddot{S}i + 6\dot{H}$	$= (\frac{2}{3}\dot{R}^3 + \frac{1}{3}\ddot{A}l)\ddot{S}i + 2\dot{H}$
Euphyllite,	$\dot{R}^3\ddot{S}i + 8\ddot{A}l\ddot{S}i + 6\dot{H}$	$= (\frac{1}{9}\dot{R}^3 + \frac{8}{9}\ddot{A}l)\ddot{S}i + \frac{1}{3}\dot{H}$

II. *General Formula* $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{3}{2}} + Aq.$

Pyrosclerite (B),	$3\dot{R}^3\ddot{S}i^{\frac{3}{2}} + 2\ddot{R}\ddot{S}i^{\frac{3}{2}} + 7\frac{1}{2}\dot{H}$	$= (\frac{3}{5}\dot{R}^3 + \frac{2}{5}\ddot{R})\ddot{S}i^{\frac{3}{2}} + 1\frac{1}{2}\dot{H}$
Clinochlore,† Chlorite,	$5\dot{R}^3\ddot{S}i^{\frac{3}{2}} + 3\ddot{R}\ddot{S}i^{\frac{3}{2}} + 12\dot{H}$	$= (\frac{1}{2}\dot{R}^3 + \frac{1}{2}\ddot{R})\ddot{S}i^{\frac{3}{2}} + 1\frac{1}{2}\dot{H}$
Delessite,	$\dot{R}^3\ddot{S}i^{\frac{3}{2}} + \ddot{R}\ddot{S}i^{\frac{3}{2}} + 3\dot{H}$	$= (\frac{1}{4}\dot{R}^3 + \frac{1}{4}\ddot{R})\ddot{S}i^{\frac{3}{2}} + 1\frac{1}{2}\dot{H}$

III. *General Formula* $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{4}{3}} + Aq.$

Ripidolite,	$\dot{R}^3\ddot{S}i^{\frac{4}{3}} + \ddot{R}\ddot{S}i^{\frac{4}{3}} + 3\dot{H}$	$= (\frac{1}{4}\dot{R}^3 + \frac{1}{4}\ddot{R})\ddot{S}i^{\frac{4}{3}} + 1\frac{1}{2}\dot{H}$
Aphrosiderite,	$\dot{F}e^3\ddot{S}i^{\frac{4}{3}} + \ddot{R}\ddot{S}i^{\frac{4}{3}} + 2\dot{H}$	$= (\frac{1}{4}\dot{F}e^3 + \frac{1}{4}\ddot{R})\ddot{S}i^{\frac{4}{3}} + \dot{H}$
Clintonite,	$\dot{R}^3(\ddot{S}i, \ddot{A}l)^{\frac{4}{3}} + \ddot{R}(\ddot{S}i, \ddot{A}l)^{\frac{4}{3}} + \dot{H}$	$= (\frac{1}{4}\dot{R}^3 + \frac{1}{4}\ddot{R})(\ddot{S}i, \ddot{A}l)^{\frac{4}{3}} + \frac{1}{4}\dot{H}$
Chloritoid (A),	$\dot{R}^3\ddot{S}i^{\frac{4}{3}} + 2\ddot{A}l\ddot{S}i^{\frac{4}{3}} + 3\dot{H}$	$= (\frac{1}{2}\dot{R}^3 + \frac{1}{2}\ddot{A}l)\ddot{S}i^{\frac{4}{3}} + \dot{H}$

IV. *General Formula* $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{1}{2}} + Aq.$

Chloritoid (B),	$\dot{R}^3\ddot{S}i^{\frac{1}{2}} + 3\ddot{A}l\ddot{S}i^{\frac{1}{2}} + 3\dot{H}$	$= (\frac{1}{2}\dot{R}^3 + \frac{1}{2}\ddot{A}l)\ddot{S}i^{\frac{1}{2}} + \frac{1}{2}\dot{H}$
Margarite,	$(\dot{R}^3, \dot{H}^3)\ddot{S}i^{\frac{1}{2}} + 3\ddot{A}l\ddot{S}i^{\frac{1}{2}}$	$= (\frac{1}{2}(\dot{R}, \dot{H})^3 + \frac{1}{2}\ddot{A}l)\ddot{S}i^{\frac{1}{2}}$
Cronstedite,	$\dot{R}^3\ddot{S}i^{\frac{1}{2}} + \ddot{R}\ddot{S}i^{\frac{1}{2}} + 3\dot{H}$	$= (\frac{1}{2}\dot{R}^3 + \frac{1}{2}\ddot{A}l)\ddot{S}i^{\frac{1}{2}} + 1\frac{1}{2}\dot{H}$
Sideroschisolite,		$\dot{F}e^3\ddot{S}i^{\frac{1}{2}} + 1\frac{1}{2}\dot{H}$

* The first of these formulas of Pyrosclerite corresponds to Silica 37·6, alumina 14·2, magnesia 33·2, water 14·9; the second, (which accords with the ratio obtained by Hermann), to Silica 32·6, alumina 19·8, magnesia 34·6, water 13·0. Other analyses, as those by Genth, and Smith and Brush, afford an intermediate ratio.

† Clinochlore has for $\dot{R}^3 : \ddot{R}$ nearly the ratio 7 : 4, instead of 5 : 3.

These formulas belong to a single system or natural Group, and exhibit in a simple manner the relations of the species. Chloritoid and margarite are often associated together with corundum.

The second formula of Chloritoid corresponds to a recent analysis by Prof. von Kobell of a specimen from Bregratten, in the Tyrol, and to that by Dr. J. L. Smith of Asia Minor specimens.

The water is not regarded as a base in the above, excepting in the case of margarite. This independent relation of water is illustrated in other crystallized hydrous silicates. Thus *Pectolite*, has the crystalline form of hornblende; and *excluding the water*, its formula. So also *Laumonite* has in a similar manner the form and formula of Pyroxene, and in fact it is a hydrous Spodumene. Dioptase and Pyrosmalite, likewise, have the form and formula of Beryl and Eudialyte, as shown on page 211, vol. xvii, of this Journal; *Tritomite* the form and formula of garnet; while *Analcime* is a hydrous Leucite, and *Ittnerite* essentially a hydrous Sodalite. These are some of the examples among minerals, which show through homœomorphism, that the water in hydrous silicates is sometimes not a base.

In other cases, the water must be included among the bases: and this may be the fact with Apophyllite. The formula $(\dot{C}a, \dot{K})\ddot{S}i + 2\dot{H}$ (Rose) gives 3 per cent. too little of silica. But taking the exact ratio afforded by the analyses, as deduced by Berzelius, and making part of the water basic, we arrive at the formula $\dot{R}^3\ddot{S}i^2 + 2\dot{H} =$ Silica 52·7, lime 2·60, potash 4·4, water 16·7, in which $\dot{R}^3$ corresponds to $\dot{C}a, \dot{K}, \dot{H}$ in the proportions 8 : 1 : 6. Datholite is a less doubtful example, giving nearly the form and formula of Sphene.

It will be observed, that in most of the species following Pyrosclerite A, if the oxygen of the water be added to that of the bases (see table, p. 128), its ratio to that of the Silica is then 2 : 1, on which ground, if the water be basic, the general formula of these species would be $(\dot{R}^3, \ddot{R}, \dot{H}^3)\ddot{S}i^{\frac{1}{2}}$.

Wöhlerite.—The formula of Wöhlerite deduced by Scheerer is $\dot{Z}r^3\ddot{S}i + 5(\dot{N}a\ddot{S}i + \dot{C}a^3\ddot{S}i)$. It is certainly improbable that the same compound should contain three members so unlike in ratio, one with the oxygen of base and acid as 3 : 1, a second with this ratio 1 : 3, and a third, of 1 : 1. The analysis gives more exactly $4\dot{N}a$ and $14\dot{C}a$; and thence the oxygen of the silica is to that of the other ingredients as 1 : 1, giving the general formula $(\dot{R}^3, \dot{Z}r, \dot{N}i)\ddot{S}i$, in which $\dot{N}i : \dot{Z}r : \dot{R}^3 = 1 : 3 : 6$ and affording the special formula $6\dot{R}^3\ddot{S}i + 3\dot{Z}r\ddot{S}i + \dot{N}i\ddot{S}i$, or $(\frac{6}{10}\dot{R}^3 + \frac{3}{10}\dot{Z}r + \frac{1}{10}\dot{N}i)\ddot{S}i =$ Silica 31·2, niobic acid 14·3, zirconia 18·9, lime 27·0, soda 8·6.

Keilhauite.—The formula of this mineral, according to Erdmann, is $3\dot{C}a^3\ddot{S}i^2 + \ddot{R}\ddot{S}i + \dot{Y}\dot{T}i^3$, which contains three members with the widely unlike ratios 1 : 2, 1 : 1, 1 : 6. Erdmann's analyses afford the oxygen ratio for the bases and silica, (reckoning the $\dot{T}i$ with the former) of 3 : 2. Sphene has the same ratio, and I have shown that this mineral is a silicate of the form $\ddot{R}\ddot{S}i^{\frac{2}{3}}$, in which $\ddot{R}$ or $(R^2O^3) = TiO^2 + CaO$, lime replacing part of the peroxyd. In Keilhauite the lime $(\dot{C}a)$ is nearly sufficient to make a peroxyd if combined with the $\dot{T}i$. Consequently Keilhauite appears to be a silicate analogous to Sphene, with the general formula $(\ddot{R})\ddot{S}i^{\frac{2}{3}}$ or $(\dot{R}^3, \ddot{R})\ddot{S}i^{\frac{2}{3}}$.

To Table I. of this volume, page 42, add :—

Æschynite, $I : I = 90° 34'$, $1\breve{1} : 1\breve{1} = 111° 56'$, $1\breve{1} : 1\breve{1} = 112° 28'$. The plane I is $i\breve{2}$ (∞ P$\breve{2}$) of Rose. $a : b : c = 0{\cdot}67534 : 1 : 1{\cdot}01$.

Zinc Vitriol. $I : I = 90° 42'$, $1\breve{1} : 1\breve{1} = 120° 20'$, $1\breve{1} : 1\breve{1} = 120° 3'$; $a : b : c = 0{\cdot}5735 : 1 : 1{\cdot}0123$. Near Epsomite.

Libethenite. $I : I = 92° 20'$, $1\breve{1} : 1\breve{1} = 107° 40'$, $1\breve{1} : 1\breve{1} = 109° 52'$, $a : b : c = 0{\cdot}7311 : 1 : 1{\cdot}0416$.

To Table II, page 47, add :—

Descloizite, Damour (Vanadate of lead, vol. xvii, of this Jour., p. 434)—$I : I = 100° 38'$; $1\breve{1} : 1\breve{1} = 67° 36'$, $1\breve{1} : 1\breve{1} = 77° 47'$; $a : b : c = 1{\cdot}494 : 1 : 1{\cdot}2052$. The striated planes $c\frac{3}{2}$ are here regarded as parallel to the vertical axis, which makes M a brachydome; and it becomes the brachydome $\frac{1}{2}\breve{1}$, having the summit angle 116° 25′. Taking this as $1\breve{1}$ instead of $\frac{1}{2}\breve{1}$, the vertical axis has half the above length or 0·747, the other axes being the same.

Glaserite (Anhydrous Sulphate of Potash). $I : I = 104° 52'$, $1\breve{1} : 1\breve{1} = 59° 31'$, $1\breve{1} : 1\breve{1} = 73° 14'$; $a : b : c = 1{\cdot}749 : 1 : 1{\cdot}3$.

Thenardite. $I : I = 103° 26'$, $1\breve{1} : 1\breve{1} = 61° 12'$, $1\breve{1} : 1\breve{1} = 73° 42'$; $a : b : c = 1{\cdot}691 : 1 : 1{\cdot}267$.

Struvite. $I : I = 101° 42'$, $1\breve{1} : 1\breve{1} = 85° 4'$, $1\breve{1} : 1\breve{1} = 96° 50'$; $a : b : c = 1{\cdot}0900 : 1 : 1{\cdot}2283$. The cleavage plane is here made the base, and the prism of 96° 50′ the unit brachydome. The crystals are hemihedral (or hemimorphic) in the direction of the brachydiagonal. The species belongs near Hopeite, of Section III, Table II. If the domes $1\breve{1}$ and $1\breve{1}$ be taken as the domes $\frac{2}{3}\breve{1}$ and $\frac{2}{3}\breve{1}$, (see page 48 of this volume) then $1\breve{1} : 1\breve{1} = 62° 54'$, *and the dimensions are very near those of Heavy Spar;* $a : b : c = 1{\cdot}6350 : 1 : 1{\cdot}2283$, a here being one half greater than above.

To Table in last volume, on pp. 432, 433, add :—

Faujasite, Dimetric, Section IV; $O : 1 = 118° 16'$, $O : 1\breve{1} = 127° 15'$.

Edingtonite, Dimetric, Section II; $O : 1 = 136° 20\frac{1}{2}'$.

Gismondine, Dimetric, Section VI; $O : 1 = 133° 45'$, equals $O : \frac{1}{2}$ in Scheelite.

Alunite, Rhombohedral, Section IV; $O : R = 124° 40'$, $R : R = 89° 10'$. One of the occurring rhombohedrons ($\frac{6}{5}$R) gives the angles of the rhombohedron of Brucite; $O : \frac{6}{5} = 119° 57'$, $\frac{6}{5} : \frac{6}{5} = 82° 26'$.

Levyne may be added to the Calcite Group; $O : 1 = 136° 1'$. The other species of Section II are evidently closely related to the same Group.

On p. 217, last volume, "C = 106° 8′" and "C = 88° 46′" should be transposed.

In the *Dimetric System* (p. 433, vol. xvii,) the two groups of species pointed out as belonging to a distinct series of angles—one the *Rutile* Group, the other the *Idocrase* Group,—differ 3 to 5 degrees in the inclination of the base on the corresponding pyramidal planes, or twice this amount in the basal angle of the pyramids. In the former the basal angle of one pyramid is mostly 4 to 7 degrees above 90°; and in the latter 1 to 6 degrees less than 90°.

III. Botany and Zoology.

1. *The Micrographic Dictionary; a Guide to the Examination and Investigation of the Structure and Nature of Microscopic Objects;* by J. W. Griffith, M.D., F.L.S., and Arthur Henfrey, F.R.S., F.L.S., &c. Part 1. May, 1854. London: Van Voorst. pp. Introd. 24, Dictionary 16, plates 4. 8vo.—The first fasciculus of a work which is likely to supply an acknowledged want, and to be extensively useful. It is intended to be completed in 12 monthly parts (2*s.* 6*d.* each), illustrated by 40 plates, and about 800 wood-engravings. The subjects to which it is devoted are: 1. Instruction in the selection and use of Microscopes and microscopic objects. 2. The characters and structure, &c., of microscopic plants and animals, and minute organs, intimate struc-

ture, &c., in both kingdoms, and also inorganic matters occurring in animal and vegetable fluids, &c. The Dictionary extends in this fasciculus only from *Acalephæ* to *Aerial Roots*. The Introduction, on the selection, use, &c., of a microscope and its accessories, which appears to be exceedingly well executed, will be completed in part 2. The plate of test objects is admirably drawn and engraved: the other plates are tolerably good. No doubt the work will be in the hands of our microscopists generally. A. G.

2. *Botany of the Voyage of the Herald;* by B. SEEMANN.—The 4th part, (London, Reeve, 1854,) continues the Flora of Panama from the *Lythrarieæ* to the *Compositæ*, and about half way through the latter order, which is remarkably well elaborated by Dr. Steetz of Hamburgh. To the *Passifloraceæ* Mr. Seemann has annexed the *Turneraceæ*, on the strength of characters furnished by a new Veraguan genus, *Erblichia*, Seemann. The reasons of the union are more fully explained in a short article published some time ago in Hooker's Journal of Botany. A. G.

3. *Dr. Hooker's Flora of New Zealand.* Part 5, (London, 1854, Reeve,) commences the account of the Cryptogamic Plants, which are so numerous in New Zealand. Dr. Hooker has himself elaborated the Ferns, with a bold and able hand; and his prefatory observations upon this beautiful order,—so perplexed of late by special Fern-systematists, who, some of them, propose new genera for every modification of any one organ, whether of vegetation or reproduction,—deserve an attentive consideration. Under *Hymmenophyllum Tunbridgense*, "a scarce English Fern," there is perhaps some mistake in the statement that it is "a great favorite with cultivators;" for we had supposed that no person had yet succeeded in cultivating it. Mr. Wilson has elaborated the *Musci*, in the midst of which the present fasciculus closes: seven plates are given to their illustration, and more are apparently to come. We understand that this great work will be immediately followed by the *Flora of Tasmania;* and that the first part of the Flora of India is also ready for the press. A. G.

4. *Botany of the U. S. Exploring Expedition under Capt. Wilkes: Phanerogamia*; by A. GRAY. Vol. I. pp. 777, roy 4to.—This volume contains the *Exogenæ Polypetalæ*. Many new species, and the following new genera are established in it, viz:

Richella—in Anonaceæ, near Polyalthia of Blume, but with a singular winged seed.

Agatea and *Isodendrion*, in Violaceæ; the latter of three species.

Diclidocarpus, a remarkable Tiliaceous genus.

Draytonia, allied to Saurauja, but with the styles united into one.

Rhytidandra, an anomalous Olacineous genus.

Pelea, a Rutaceous (Zanthoxylaceous) genus, of seven species.

Amaroria; a near ally of Soulamea, the *Rex amaroris* of Rumphius.

Brackenridgea; a genus of Ochnaceæ.

Oncocarpus; a genus of Anacardiaceæ, with a remarkable fruit.

Streptodesmia; a near ally of Adesmia.

Luma; a new Myrtaceous genus, of numerous Chilian species.

Acicalyptus; a genus related to Calyptranthes and Eucalyptus, to which the more closely can only be known by the fruit, which, however, is probably baccate.

Astronidium and *Pleiochiton*, two genera of Melastomaceæ.

Haplopetalon; a new genus of Legnotidæ, to which group *Crossostylis* is also referred.

Spiræanthemum; of Saxifragaceæ, Cunonieæ, containing two species.

Reynoldsia (of two species), *Tetraplasandra*, and *Plerandra*, new Araliaceous genera; the two latter with numerous or indefinite stamens; a new feature in this family.

The folio Atlas, of 100 plates, is not yet issued. A. G.

5. *Dr. Wallich*, the distinguished East Indian Botanist (a Dane by birth) died in London, at the close of April last. A little earlier the venerable *Professor Reinwardt* died in Holland. A. G.

6. *On preserving the Balance between the Animal and Vegetable Organisms in Sea Water*; by ROBERT WARINGTON,* (Ann. Mag. Nat. Hist., 2nd ser., vol. xii, p. 319.)—In the published notices of my experiments of 1849, to maintain the balance between the animal and vegetable organisms in a confined and limited portion of water, the fact was demonstrated, that, in consequence of the natural decay of the vegetation, its subsequent decomposition and the mucus-growth to which it gave rise, this balance could be sustained only for a very short period, but if another member were introduced, which would feed upon the decaying vegetation and thus prevent the accumulation of these destructive products—a function most admirably performed by the various species of water-snail—such balance was capable of being continuously maintained without the slightest difficulty; and I may add, that the experimental proof of this has now been carried on, in a small tank in the heart of London, for the last four years and a half, without any change or disturbance of the water; the loss which takes place by evaporation being made up by rain or distilled water, so as to avoid any great increase of the mineral ingredients originally present. It follows then, as a natural deduction, from the successful demonstration of these premises, that the same balance should be capable of being established, under analogous circumstance, in sea water. And in a paper published in January, 1852,† I stated that I was, at that time, "attempting the same kind of arrangement with a confined portion of sea water, employing some of the green sea-weeds for the vegetable member of the circle, and the common periwinkle as the representative of the water-snail."

The sea water with which the experiments I am about to detail were conducted, was obtained through the medium of one of the oyster-boats at the Billingsgate fish-market, and was taken from the middle of the English Channel.

My first object was to ascertain the kind of sea-weed best fitted, under ordinary circumstances, for keeping the water clear and sweet, and in a sufficiently oxygenated state to sustain animal life. And here opinions were at variance, for one naturalist friend whom I consulted, advised me to employ the Rhodosperms; another stated that it was impossible to make the red weeds answer the purpose, as he had tried them, and strongly recommended the olive or brown-colored Algæ;

* Communicated by the Author, having been read at the Hull Meeting of the British Association.

† Gardeners' Botanical Magazine and Garden Companion, Jan., 1852.

while, again, others thought that I should be more successful with those which had in theory first suggested themselves to my own mind, namely the Chlorosperms. After making numerous unsuccessful experiments with both the brown and red varieties of Algæ, I was fully convinced that, under ordinary circumstances, the green weeds were the best adapted for the purpose.

This point having been practically ascertained, and some good pieces of the *Enteromorpha* and *Ulva latissima* in a healthy state, attached to nodules of flint or chalk, having been procured from the shore near Broadstairs, several living animal subjects were introduced, together with the periwinkle. Every thing progressed satisfactorily, and these all continued in a healthy and lively condition.

My first trials were conducted in one of the small tanks which had been used for fresh water; but as it was necessary, during the unsuccessful experiments with the brown and red sea-weeds, to agitate and aërate the water, which had been rendered foul from the quantity of mucus or gelatinous matter generated during the decay of their fronds, until the whole had become oxydized, and the water rendered clear and fitted for another experiment, it was, therefore, for greater convenience, removed into a shallow earthen pan and covered with a large glass shade to protect the surface of the water, as much as possible, from the dust and soot of the London atmosphere, and at the same time impede the evaporation. In this vessel then I had succeeded perfectly in keeping a large number of beautiful living specimens in a healthy condition up to the close of 1852. I therefore gave instructions for the making of a small tank as a more permanent reservoir, and one more adapted for carrying on my observations and investigations on the economy and habits of the inhabitants.

From the experience I had obtained in my experiments with the freshwater tank, I was induced to modify slightly the construction of this vessel; thus, at the back, or part towards the light, the framing was filled with slate in the same way as the ends and bottom; for I had found that the glass, originally employed, very soon became covered with a confervoid growth which had an unpleasing appearance to the eye, and in consequence of which I had been obliged to paint the glass on the exterior, to prevent this growth from increasing to too great an extent. It was also an unnatural mode of illumination, as all the light should pass through the surface of the water. The front towards the room and the observer was constructed of plate-glass, the whole being set in a stout framework of zinc, and cemented with what is known under the name of Scott's cement, and which I have found to answer the purpose most admirably. Within this tank were arranged several large pieces of rock-work, thrown into an arched form, and other fragments were cemented in places against the slate at the back and ends, and at parts along the water line, so that the creatures could hide themselves at pleasure; a short beach of pebbles was also constructed in order that shallow water could be resorted to if desired. The whole tank was covered with a light glass shade to keep out the dust and retard evaporation.

With the sea water obtained in January, 1852, I have been working without cessation up to the present time, agitating and aërating when it

became foul during the unsuccessful experiments on the sea-weeds, but since then it has been rarely ever disturbed; the loss which takes place from evaporation being made up, as before stated, with rain or distilled water.

For a considerable period, after commencing these experiments, I was much troubled to obtain living subjects in a healthy condition, but having alluded to this, and the success of my investigations, in a short notice appended to a paper published in the "Annals of Natural History" for October, 1852, my friend, Mr. P. H. Gosse, who was then sojourning at Ilfracombe for his health, offered in the kindest manner to supply me with materials, and from that period he has always most heartily responded to my wants. It must not be imagined for a moment that the beautiful creatures I have thus received have been all preserved alive or always quite healthy. In experimental investigations this would be unreasonable to expect, as the very fact of experimenting implies a disturbance of the then state of things. Besides which, from want of a sufficient knowledge of natural history, from want of forethought and experience and other causes, I have lost many very fine specimens; and as the detail of these losses may prevent the occurrence of the like annoyances to others, I shall venture to occupy your time for a short period with their history.

My greatest loss arose from too great anxiety to transfer the collection I had preseved in a healthy condition to the end of December, 1852, into the new tank. As soon as it arrived from the maker's I lost no time in introducing my numerous family to their new abode, and dearly I paid for my precipitancy, for on the next morning I found many of my most beautiful specimens dead; thus I lost two fine Holothurias *(H. Pentactes)*, a small freckled Goby *(Gobius minutus)*, a beautiful little Pipe-fish *(Syngnathus lumbriciformis)*, and several others, and on opening the door of the case the cause of this mortality was at once evident,—an iridescent film of oily matter was floating on the surface of the water, arising from the paint with which the angular joints and edges of the small tank had been colored not having become sufficiently hardened.

Another source of loss arises from the several creatures attacking and devouring each other, and it therefore becomes a point of great importance—and highly necessary to be carefully observed, where their preservation is an object—to ascertain what varieties may be safely associated in the same tank; as, for instance, I have found that the Shrimps, and Prawns attack, and very soon devour, all the larger varieties of Corallines and Polyps, Sabellæ, Serpulæ, Rock-borers, Cirrhipeds, some of the Annelids, many of Bivalve and Univalve Mollusks that are unprotected by an operculum, or have no power of closing their valves. The instances which have come under my own immediate observation have been the destruction of the *Pholas dactylus*, *Saxicava rugosa*, *Cypræa Europæa*, and several specimens of Sabellæ, Serpulæ, *Coryne sessilis* and many others.

The common Crab *(Cancer Mænas)* is likewise a most destructive agent; and the tribe of rock-fish, the Blennies, Gobies, &c. are also most voracious, devouring all the varieties of Cirrhipeds, Corallines, Polyps, Annelids, &c.; they will also attack the shrimps and prawns,

and even seize upon the horns of the periwinkle, which they bite. If the mollusks do not keep a very firm hold of the rock or tank sides, they are rapidly turned over by these fish on their backs and lie helplessly exposed to their attacks.* It is doubtless their seeking food of this kind which causes these little fish to be so generally found in the shallow rock-pools of the coast. In consequence of these ravenous propensities I have been obliged to establish several small tanks and imitation rock-pools, so as to separate these various depredators from each other: thus in one I have varieties of *Actinia*, Shrimps, Nudibranchs, Holothurias, and some Annelids; in a second the rock-fish, as the Blennies, Gobies, Cottus, with Crabs and *Actiniæ;* in a third Corallines, Annelids, Polyps, Rock-borers, Sabellæ, Serpulæ, Holothurias, and *Actiniæ*.

Another curious instance of loss I may detail which has quite recently occurred, and which may prove interesting; it was in a small rock-pool containing Blennies, Gobies, Crabs, &c. I had procured two live oysters for the purpose of feeding my numerous small fry in these Vivaria, and one of these having proved ample for the purpose of one meal, the other was placed on the sandy bottom; on the second day after this, the oyster was observed to have opened the valves of his shell to a great extent, which were afterwards seen closed, but a small *Gobius niger*, inhabiting the pool, could nowhere be seen. The day after this the oyster was opened for the general feeding, when lo! within the shell was found the unfortunate *Gobius*, quite dead. Whether this little gentleman had been attracted within the trap by curiosity or the ciliary motion of the oyster, it is impossible with certainty to say; but that he must have seized on some sensitive part of the oyster is more than probable, so as to have caused such a rapid closing of the valves of the shell as could entrap so active a burglar.

Another important point is the gravity of the sea water; this should be very carefully regulated, for it must be borne in mind that many of the marine creatures are supplied by a permeation of water through their tissues or over their delicate and beautiful organs. The specific gravity should not rise above 1026 at 60° Fahr., and a small hydrometer should be introduced at short periods to ascertain that this point is not exceeded, particularly during the hot months of summer. The reduction to this gravity can be readily effected by the addition of rain or distilled water. Many of the creatures will of themselves afford indications of this increase of density; some of the *Actiniæ* will remain closed and become coated with a white slimy covering within which they remain for a length of time, and if the specific gravity of the water be lowered this is very soon ruptured by their expansion, thrown off, and the tentacula become soon extended.

* Since the reading of this paper at Hull I have received a Blenny of larger size, being about 3½ inches in length, and although it has become so tame that it will allow itself to be touched by the hand and takes its food from the fingers, yet its destructive propensities are so great, that it very soon killed four small Crabs; and to save three others, of rather a larger size, I have been obliged to remove the Blenny to a rock-pool in association with his own species and a few *Actiniæ*. The only refuge the poor Crabs had was to bury themselves in the sand, and whenever they attempted to move out of their refuge they were immediately pounced upon and only escaped by burrowing rapidly again.

All putrescent matter or excess of food or rejecta of the *Actiniæ* should be carefully removed from the water, as the noxious gaseous compounds generated by the decay of such matters appear to diffuse themselves rapidly through the water, act as a virulent poison, and speedily destroy the vitality of the occupants. Thus many beautiful subjects were lost in a few hours from the introduction, into a small glass jar, of a large Pecten shell, encrusted with corallines, which had become loaded with putrescent matter by partial submersion in a foul muddy bottom.

Great care should also be taken in moving the *Actiniæ*, that the foot or sucking disc with which it attaches itself to the rocks, stones, or mud, be not injured, as, when this occurs, they rarely survive, but roll about without attaching themselves, and gradually waste away and die.

With these exceptions then, every thing has gone on very satisfactorily, care being always taken not to overload the water with too large a proportion of animal life for the vegetation to balance, as whenever this has been inadvertently attempted, the water has soon become foul, and the whole contents of the tank, both animal and vegetable, have rapidly suffered, and it has required some time before the water could be restored to its former healthy condition.

In one of the numbers of the "Zoologist" of last year, I stated that besides the *Ulvæ*, *Enteromorphæ* and *Cladophoræ*, I had found the *Zostera marina* a very useful plant for oxygenating the sea water; but this observation has reference only to the case of a tank supplied with a ground where its roots will find a sufficiency of food for its growth, as in a clear shingle or sand it soon decays; and it should be associated with such animals as delight in a ground of this nature, as many of the Annelids, Crabs, burrowing Shrimps, &c. There are several interesting observations which have been made from time to time connected with this subject, which I hope to lay before the natural-history world as soon as I can find leisure time for the purpose.

Apothecaries' Hall, Sept. 10, 1853.

IV. Astronomy.

1. *New Planets:—Bellona* (28), (Comptes Rend., xxxviii, 455, 561.)—On the first of March, 1854, Mr. Luther, Director of the Observatory at Bilk, discovered a new planet which has received from Mr. Encke the name *Bellona:* it is of the tenth magnitude. Its position, March $6^d\ 10^h\ 27^m\ 30^s$, M. T. Hamburg was R. A. 180° 35′ 38″ and Dec. + 7° 47′ 34″. Mean daily motion in R. A. 10′ 7″ decreasing, in Dec. 9′ 26″, increasing.

Amphitrite (29), (Compt. Rend., xxxviii, 428, 645.)—Mr. Albert Marth, at the Regent's Park Observatory in London, discovered another planet near *Spica Virginis*, on the morning of the second of March. It appears as a star of the tenth magnitude. Mr. Bishop has proposed for it the name *Amphitrite*. The following elements of its orbit were calculated by M. Yvon Villarceau, according to the method given in the *Connaissance des Temps* for 1852, from 16 observations made at Paris during the month of March.

Epoch 1854, March 0·00, M. T. Paris.

Mean anomaly,	114° 36′ 54″·58	
Long. perihelion,	64 50 22 ·81	Mn. Eqnx.
" asc. node,	356 20 34 ·94	Mar. 0·0, 1854.
Inclination,	6 6 19 ·69	
Angle of excentricity,	4 34 47 ·04	
Mean daily motion,	864″·3666	
Semi-axis major,	2·5637300	
Period of revolution,	4^{yrs}·104962	

This planet was discovered independently by M. Chacornac, assistant observer at the Observatory of Paris, on the third of March. He also on the fourth of February, at Marseilles, noted a star of the tenth magnitude which is now wanting in that place, and which is shown to have been the body first recognized as a planet by Mr. Marth.

2. *New Comet, I. of* 1854, (Comptes Rend., xxxviii, 648.)—The comet which was visible to the naked eye on the twenty-ninth of March last and the few following days, was seen on the same day in Paris. The following elements were computed by Mr. James Ferguson (Astron. Journ., No. 71,) from the Washington observations of April 3, 7 and 11.

Perihelion passage, 1854, March 24·0581, M. T. Berlin.

Long. perihelion,	214° 52′ 52″·0	Mn. Eqnx.
" asc. node,	316 19 58 ·2	Apr. 7·0, 1854.
Inclination,	83 30 33 ·4	
Log. perihelion dist.,	9·441070	
Motion,	Retrograde.	

This comet was seen in the east on the morning of the twenty-third of March by Mr. Alfred de Menciaux near Damazan in France.

3. *Annular Solar Eclipse of May* 26, 1854.—From a communication in the Boston Evening Traveler, May 29, 1854, we gather some of the following particulars respecting the solar eclipse of May 26, 1854. On account of cloudy weather, the eclipse was but partially observed throughout New England, and in many places wholly lost. At Cambridge, Mass., the formation of the ring was observed and it occurred within seven seconds of the time predicted by R. T. Paine, Esq. in his communication to the American Academy,—which is a remarkably close coincidence. The formation and rupture of the ring and the two other contacts were concealed by clouds. "At Middlebury, Vt. where the eclipse, by calculation was central, the beginning of the eclipse could not be seen, but the formation and breaking of the ring and the end of the eclipse were finely observed, and the spectacle was magnificent." At the Coast Survey station on the summit of Mount Agamenticus, nearly in the central line, the sun was invisible throughout the day.

At New York City, Ogdensburg, and Washington, the sky was very favorable, and good observations of the phenomena were secured, including numerous heliotypic pictures with the times of each.

Effect on the Deviation of the Magnetic Needle.—Mr. J. G. Ellery sends us an account of observations made by him at Morgantown, Burke Co., N. C., on the deviation of the magnetic needle. The instrument with which his observations were made was a miner's compass,

with a needle between two and three inches in length, possessing the delicacy of movement of the best surveyor's compass, but without levels or vernier. The weather was warm and sultry, with indications of rain from some of the large clouds in different parts of the heavens; but with hardly air enough stirring to move a leaf. No motion of the needle was observed between 1 P. M. and 4 P. M. Soon after it was observed to shift its position toward the west, and at 5¼ it had attained its greatest variation, pointing then more than half a degree to the west of north. The variation decreased from that time till a quarter past six, when the needle was again precisely on the meridian. In the circumstances of the observation it seems quite uncertain whether the movement of the needle was not due to other causes than the interception of solar influence.

Lieut. MAURY (Ast. Journ., No. 72) communicates the observations made at the Washington Observatory:—

Beginning by Mr. Ferguson,	-	-	$4^h\ 2^m\ 37^s{\cdot}57$
End, "	-	-	$6\ 27\ 26{\cdot}46$
" by Prof. Keith,	-	-	$6\ 27\ 29{\cdot}64$

Mr. Ferguson observed with the large equatorial, and Prof. Keith with the west transit instrument, lifted from its Ys and mounted on the reversing apparatus. The computed times for beginning and end were $4^h\ 2^m\ 41^s{\cdot}4$ and $6^h\ 27^m\ 29^s{\cdot}4$.

Prof. JAMES CURLEY (Astr. Journ., No. 72) furnishes the observations made at the Georgetown Observatory. The last contact was observed by Prof. Sestini with the equatorial, using a power of 25 or 30, in order to have the whole sun in the field of view. The time was determined with the meridian circle from the transit of the sun on the 26th, and after applying the necessary corrections was determined to be for the last contact $6^h\ 27^m\ 22^s{\cdot}67$, Georgetown Mean Time. Lat. 38° 54′ 26″ N., Long. $5^h\ 8^m\ 18^s{\cdot}2$ west of Greenwich.

Effect on the Magnetic Intensity; by LEWIS R. GIBBES.—The condition of the atmosphere throughout the day was unfavorable to nice observations, and we have but few positive results to record. Though the face of the sun during the eclipse was not observed, yet a thin hazy cloud overspreading its disc, and the western part of the sky, and the accompanying unsteadiness of the atmosphere in refractive power, kept the limbs of both sun and moon in a state of constant agitation. This tremulous condition of the limbs prevented the study of those remarkable phenomena sometimes seen at the contact of the limbs of the two bodies.

The beginning of the eclipse was observed at $3^h\ 58^m\ 31{\cdot}4^s$ mean time at Charleston Observatory, the end at $6^h\ 19^m\ 08{\cdot}8^s$. Place of observation, the College. Magnifying power used, 55. Screen glass, green and light red combined. No unusual phenomena observed; limbs tremulous at both contacts. No spots, either dark or bright, to be seen on the sarface of the sun. No prolongation of the moon's limb beyond the sun's disc was observed, nor any alteration of the form of the cusps; nor was the moon seen before the contact of limbs, through either the white or colored screens.

The temperature and transparency, or rather transcalescency of the atmosphere was so constantly varying, that no results of interest could be obtained with reference to the eclipse.

Within the last two or three years, M. Lion, Professor of Physics at Beaune, in France, has maintained that the intensity of the magnetic force of the earth is increased during a solar eclipse. To test this, observations were made during the late eclipse with the following apparatus: A magnetic bar, $4\frac{1}{2}$ inches long and $\frac{1}{4}$ of an inch square, weighing 400 grains, was placed in a stirrup of thin sheet brass—the two together weighing 410 grains—and, by a hook of fine wire, was suspended by 5 fibres of untwisted silk, 10 inches in length; the whole was protected by a glass receiver from agitation by currents of air, or other causes of disturbance. This apparatus was mounted on a firm stand, and placed on the stone floor of a room, in the basement story of the College, used for storing the coal for the laboratory, empty packing boxes, &c., though by no means to be regarded as a coal hole; yet may not experiments be carried on in a coal hole, if no better place can be had? A few feet north of it was placed a table for the record book, chronometer, and a small telescope, whose axis coincided with that of the magnetic bar when at rest. The time required by the magnet to accomplish 100 oscillations or double vibrations were observed at intervals during the day; the end of one oscillation, and the beginning of the next, being taken at the instant that the axis of the magnet coincided with that of the telescope, the north end of the magnet swinging from west to east. The results are contained in the following table. The approximate interval for 100 oscillations was $17\frac{1}{4}$ minutes. The first column of the table gives the time of the phases of the eclipse and of the middle of each interval occupied by 100 oscillations; the second column, the precise length of interval of each 100 oscillations.

Date.	Interval of 100 oscillations.
h. m.	min. sec.
26th—10 08, A. M.	17 15·93
12 25, P. M.	General eclipse begins.
12 51, "	17 16·20
1 08, "	17 15·58
1 25, "	17 14·80
3 16, "	17 15·64
3 35, "	General eclipse middle.
3 59, "	Eclipse begins at Charleston.
4 31, "	17 15·98
4 48, "	17 16·10
5 09, "	Eclipse middle at Charleston.
6 01, "	17 15·56
6 18, "	17 15·94
6 19, "	Eclipse ends at Charleston.
6 20, "	General eclipse ends.
29th—12 30, "	17 15·12
12 47, "	17 15·15

The observations were begun on the 26th, two hours before the beginning of the general eclipse on the earth, and continued at intervals until it ended, and two more were taken on the 29th. The results give no indication of any sudden or unusual change in the magnetic intensity during the eclipse; the intervals are not all precisely equal, but their deviations from coincidence are not greater than what are due to una-

voidable errors of observation, to imperfection in the apparatus used, and possibly to ordinary causes of disturbance. The second, third, and fourth results, which appear to be regularly diminishing, were obtained in close succession, the instant of ending the first 100 oscillations being the beginning of the second 100, and the end of the second 100 being the beginning of the third 100, as will be seen by the differences of the times, being 17 minutes. Their diminution is due to the gradually diminishing arc of vibration, the initial arc being somewhat large —8 or 10 degrees—in order to allow of 300 continuous vibrations. A more delicate suspension would have been desirable. The initial arc in the other cases was about 5 degrees, and the observations continued to 200 oscillations, except in the first and fifth results. We may from these results draw the conclusion that there were no disturbances of the magnetic intensity due to the occurrence of the eclipse, although the strictly logical deduction is, that if such disturbances existed, they were too minute to be detected by the apparatus used.

M. Lion has also maintained that this disturbing influence of a solar eclipse may be perceived at places where the eclipse is not visible. This point we examined with the same apparatus above described, at the occurrence of the solar eclipse of 6th June, 1853, which was not visible at Charleston, the northern edge of the penumbra passing just south of this city. The results are contained in the following table with the same arrangement as the preceding.

Date. June, 1853.	Interval of 100 oscillations.
h. m.	min. sec.
5th—8 09, A. M.	17 17·09
7 00, P. M.	17 16 88
6th—8 08, A. M.	17 18·45
8 25, "	17 18·00
11 47, "	General eclipse begins.
12 05, P. M.	17 16·88
12 22, "	17 17·23
2 38, "	General eclipse, middle.
3 00, "	17 18 02
4 00, "	17 18·18
5 47, "	General eclipse ends.
6 35, "	17 18·83
10 00, "	17 18 66
8th—8 00, A. M.	17 17·82
10 00, "	17 17·36

These results show no disturbance proceeding from the occurrence of the Solar Eclipse, and we cannot avoid the conclusion that the Professor at Beaune has in some way mystified himself in his observations, especially as his instrument was, if we mistake not, an ordinary magnetic compass, and therefore far less fit for such observations than the above described apparatus.

Each result in the above tables is the mean of *five* sets taken in the mode usually adopted in such observations, except the first in the first table, which is a mean of three. More, therefore, than 5000 oscillations, or more than 10,000 vibrations have contributed the results in the first table, and more than 12,000 vibrations the results of the second table.

College of Charleston, 1st June, 1854.

4. *Eclipse of the Sun, May* 26, 1854, *at Yale College*, (Lat. 41° 18′ 23″, Lon. 4h. 51m. 47s.)—The previous day was rainy, but it cleared off in the night, and the morning afforded so pure and clear a sky as to inspire high hopes of a most favorable time for observing the eclipse. But by noon a strong northwesterly wind began to bring up ridges of cumulus clouds which, as the time of the eclipse drew near, left only here and there a patch of clear sky and prevented our obtaining the first contact, although Mr. Francis Bradley who observed separately with his reflector, had a momentary glimpse of the sun at 4h. 19m. 47s. M. T. when the eclipse had advanced a few seconds. Messrs. Lyman and Newton used the Clark Telescope with a power of 110. No spots were visible, but the mottled appearance of the sun was very distinct, and the definition good. When the sun was first seen emerging from a cloud, the eclipse had advanced perhaps 15 or 20 seconds. Clouds and clear sky alternately obscured and revealed the sun until five o'clock, after which the view was unobstructed.

The *end* was closely observed by Mr. Bradley with a power of 80 and by Mr. Lyman with 110, but the limb, being now near the horizon, was so broken and wavy that the instant of last contact could not be determined within several seconds. The time fixed upon was 6h. 42m. 19s. This is probably within from 5 to 8 seconds of the truth.

Mr. Lyman remarks, that with the Clark Telescope (aperture 5 inches) the moon's limb during the early part of the eclipse, was well defined, the lunar mountains being projected with great distinctness on the sun's disk. Two or three times near the middle of the eclipse, the extreme points of the cusps were observed to be momentarily cut off by projecting mountains. No other important physical phenomena were noticed by him, though the cusps and limbs of the sun and moon were carefully watched at frequent intervals. Mr. Newton could detect no signs of polarization with a double image prism.

Professor Olmsted occupied himself with the meteorological instruments, and the general aspects of the earth and sky. He was favorably situated on the top of a high tower where an unobstructed view was enjoyed on all sides. As the eclipse advanced to the maximum (nearly 11 digits) the shadows became less deep, the color of the grass and trees, now at the height of their summer verdure, wore an increasing olive hue, and a sublime and strange appearance invested all things. Having, however, witnessed the total eclipse of June, 1806, and retained its appearances very fresh in memory, he remarked that there was an immense difference between a total eclipse of the sun, and one only *almost* total, the former being vastly more sublime and impressive.

The meteorological instruments, including the barometer, two thermometers, (one in the sun the other in the shade,) and a delicate azimuth compass, were noted at short intervals, but none of the observations suggested any thing important, except that the thermometer exposed to the direct action of the sun rapidly fell as the eclipse advanced, and at the maximum, differed only two degrees from that in the shade, the former being 69½° and the latter 67½°. At 3h. 16m. the solar thermometer had stood at 92¼°, and just after the beginning of the eclipse when the sun came out of a cloud, it stood at 82°. The sensations indicated a perceptible decline of temperature, but nothing of that chill was experienced which characterized the total eclipse of 1806. O.

V. Miscellaneous Intelligence.

1. *American Association for the Advancement of Science.*—This Association held its annual meeting at Washington, in the rooms of the Smithsonian Institution, during the week commencing with Wednesday the 26th of April, 1854. James D. Dana was the President of the meeting. Prof. J. Lovering, of Cambridge, Permanent Secretary, Prof. J. Lawrence Smith, General Secretary. Prof. John Torrey was elected President for the next meeting, which was appointed to be held in Providence, R. I., on the 3d Wednesday of August, 1855.

The following is a list of the papers read at the recent session:

(1.) *Physics, Astronomy, Geodesy, &c.*

Comparison of the diurnal inequalities of the tides at San Diego, San Francisco, and Astoria, on the Pacific coast of the United States, from observations in connection with the Coast Survey. By *A. D. Bache*, Superintendent.

On the resistance experienced by bodies falling through the Atmosphere. By Prof. *Elias Loomis*, University of New York.

Electric properties of whalebone rubber. By Mr. *John M. Batchelder*, Superintendent of the Crystal Palace (communicated by Prof. Peirce).

Preliminary determination of cotidal lines on the Atlantic coast of the United States, from the Coast Survey tidal observations. By *A. D. Bache*, Superintendent.

Earthquakes of Chili. By Lieut. *Gillis*.

On the physical constitution of the sun and cometary bodies. By Prof. *W. A. Norton*.

On the periodic and occasional perturbations of the directive force of the declination of the magnetic needle. By Prof. *W. A. Norton*.

On the magnetic forces observed along the line of the boundary between the United States and Mexico. By Maj. *W. H. Emory*.

Results of some investigations respecting the double comet of Biela. By Prof. *J. S. Hubbard*, of the National Observatory.

Illustration of cycloidal curvature as involved in the supposititious travelling whirlwinds, and some new demonstrations of the impossibility of storms being whirlwinds, unless on a limited scale, as the consequence of in-blowing winds. By Prof. *Robert Hare*.

Suggestion relative to the observation of the annular eclipse of the sun of May 26, 1854. By *Stephen Alexander*.

On the distribution of temperature in and near the Gulf Stream, off the coast of the United States, from observations made in the Coast Survey. By *A. D. Bache*, Superintendent.

On the Gulf Stream. By Lieut. *M. F. Maury*.

On the Basin of the Atlantic. By Lieut. *M. F. Maury*.

Astronomical determination of the sun's diurnal and annual intensity. By *L. W. Meech*.

On the transparency of the ocean. By Commander *Glynn*, U. S. N.

On the nature of Forces. By Lieut *E. B. Hunt*, Corps of Engineers, U. S. A.

Description of the U. S. Coast Survey Apparatus for measuring base lines. By Lieut. *E. B. Hunt*, U. S. A., and Assist. U. S. C. S.

Note on a new electro-chronometric method. By Dr. *Wolcott Gibbs*.

On a new instrument for facilitating the projection of great circle routes in charts, and finding by inspection the course and distance. By Prof. *W. Chauvenet*.

Comparison of the British Association Catalogue of Stars with the Greenwich Twelve Year Catalogue. By Prof. *Elias Loomis*, University of New York.

Remarkable lunar phenomenon observed at Auburn, N. Y., Feb. 16, 1843; with diagram. By *Blanchard Fosgate*, M.D.

On the arrangement of Lecture rooms, with reference to sound and sight. By Prof. *Joseph Henry*, Secretary Smithsonian Institution, Washington.

A constructive method of projecting solar eclipses. By *Chauncey Wright*, Cambridge, Mass. Presented by Lt. C. H. Davis, U. S. N.

On the superior facilities for the computation of the Lunar Ephemeris afforded by the new system of arguments introduced by Prof. Peirce into his "*Tables of the Moon.*" By *J. D. Runkle.*

On Irradiation. By Prof. *W. B. Rogers.*

On the Satellites of Uranus. By Prof. *Elias Loomis*, University of New York.

On the inverted microscope; with some remarks on the illumination of microscopical objects. By Prof. *J. Lawrence Smith*, of Louisville, Ky.

The astronomical expedition to Chili. By Lieut. *J. M. Gilliss*, U. S. N.

Abstract of a paper on the tidal currents of Long Island and approaches, from observations in connection with the United States Coast Survey. By *Charles A. Schott.*

On the longitude of Frontera, El Paso, and San Eleazario, resulting in the determination of a cardinal point of the Boundary Survey. By Maj. *W. H. Emory.*

On the relative value of the different astronomical methods of determining the longitude. By Lieut. *C. H. Davis*, U. S. N.

On the determination of the longitude of the Observatory at Cambridge from the chronometric expeditions of the Coast Survey. By *G. P. Bond.*

Difference of longitude by Moon and Star culminations. By Prof. *G. W. Coaklay.*

The longitude of America; determined by moon culminations. By Prof. *B. Peirce*, of Harvard College.

Method of observing at sea for the determination of the latitude, longitude, and variations of the compass. By *O. C. Badger*, U. S. N.

Cloverden Observatory and the Shelby College (Kentucky) Equatorial. By *B. A. Gould*, Jr., and *Joseph Winlock.*

(2.) *Meteorology.*

The Brandon tornado, Ohio, January 20, 1854. By Prof. *O. N. Stoddard*, Miami University.

Cape Verde and Hatteras hurricane and other storms. By *W. C. Redfield*, of New York.

On the probable increase of hail storms in Cuba, especially from 1844 to 1854. By *Andres Poey*, of Havanna.

An account of a storm that passed over Connecticut, August 1, 1851. By Prof. *John Brocklesby.*

On the meteorological phenomena observed at various points on the Boundary Survey. By *Marine T. W. Chandler* (read by Maj. W. H. Emory).

On the barometer off Cape Horn. By Lieut. *M. F. Maury.*

A Theory of Storms. By *T. Bassett.*

On the permanence of the principal conditions of climate. By *Lorin Blodget*, of Washington.

The climate of Chili. By Lieut. *J. M. Gilliss.*

On the swelling of springs and the re-appearance of storms before rain. By Prof. *John Brocklesby.*

The Meteorograph: a self-registering instrument for meteorological observations. By Prof. *N. B. Webster*, of the Virginia Collegiate Institute, Portsmouth, Va.

On the law of variations of atmospheric pressure through successive months of the year; and its practical application to barometric measurements of heights in the interior of Continents. By *Lorin Blodget.*

(3.) *Geology and Mineralogy.*

On the cleavage and other effects caused by trap dykes in the middle secondary rocks of Virginia. By Prof. *W. B. Rogers.*

Notice of a peculiar variety of coal from Breckenridge county, Ky. By Prof. *B. Silliman*, Jr.

On a number of mineral species. By *T. S. Hunt*, of the geological survey of Canada.

Notice of some imprints which have recently been observed in the sandstone strata at the quarries in Portland, Ct., with some remarks on this formation on the Atlantic coast of the United States. By *John Johnston*, Prof. Nat. Science Wesleyan University, Middletown, Conn.

Brief outline or general description of a remarkable fossil, not known to be described, and by some supposed to be an Ichthyodorulite. By Prof. *Wm. Hopkins*, of Genesee College, Lima, N. Y.

On the absence of the evidence of remains of fishes in all the Silurian rocks of the United States. By *James Hall.*

Is anthracite the coke of bituminous coal? By Prof. *B. Silliman*, Jr.

On phosphatic organic remains in the Palæozoic rocks. By *T. S. Hunt*, of the Geological Survey of Canada.

On the Crystalline Limestone of North America. By *T. S. Hunt*, of the Geological Survey of Canada.

Remarks upon the geological formation of the country along the line of the boundary survey, based upon the examination of Dr. Parry, made under the order of Major Emory. By *James Hall.*

On the western limits of the Cretaceous formation on the northern continent of America, as evidenced by the various collections that have been made by exploring expeditions under the direction of the government of the United States. By *James Hall.*

Geology of the lead mines of Wisconsin. By *Edward Daniels*, Geologist to the State of Wisconsin.

On the age of the so-called new red sandstone of the United States. By Prof. *W. B. Rogers.*

Red sandstone of the Connecticut River Valley, and the proofs of its Oolitic or Liassic age. By *James Hall.*

A description of a post-diluvial deposit in Campbell Co., Ky., with a catalogue of the fossil remains. By *W. H. B. Thomas*, of Cincinnati, Ohio.

Sketch of the general geological structure of the region of country in connection with the United States and Mexican boundary line. By *C. C. Parry.*

On the chemical composition and metamorphoses of some sedimentary rocks. By *T. S. Hunt*, of the Geol. Survey of Canada.

Some comparative observations on the carboniferous strata of North America. By Prof. *H. D. Rogers.*

On some phenomena of cleavage structure, and metamorphism in coal and other strata. By Prof. *H. D. Rogers.*

On the geology of the Lower Rio Bravo. By *Arthur Schott* (read by Maj. W. H. Emory).

The Silurian and Devonian systems; and the nature of the evidence for drawing a line of separation between the two systems in the United States. By *James Hall.*

Observations upon the geology of the Mauvaises Terres, Nebraska, with notices of the geographical and geological range of some of the fossils of that region. By *James Hall.*

Remarks upon a collection of Cretaceous fossils from Nebraska, and the absence of species known in the southern extension of the same formation. By *James Hall.*

Remarks upon the results of extensive and continued collections of fossil species from a portion of the Silurian rocks of New York, showing the number of species and individuals of each species obtained from a limited locality during a period of ten years. By *James Hall.*

On the reproduction of similar types or representative species in successive geological formations. Illustrated by a collection of species of the Brachiopoda from the Niagara and Lower Helderberg groups of the Palæozoic rocks of the United States. By *James Hall.*

(4.) *Chemistry.*

On the use of hydrogen gas to displace sulphuretted hydrogen in the analysis of mineral waters. By Profs. *W. B. Rogers* and *R. E. Rogers.*

Illustrations of chemical homologies. By *T. S. Hunt*, of the geological survey of Canada.

Decomposition of water at the ordinary temperature, by an alloy of zinc and antimony; with a description of a new process for procuring hydrogen. By *Josiah P. Cooke*, Jr.

A new filtering apparatus. By *Josiah P. Cooke*, Jr.

On a new form of electrical machine. By *G. C. Schaeffer.*

Researches on arseniuretted and antimoniuretted hydrogen, and their relations to Toxicology. By Prof. *Raphael Napoli*, of Naples.

On the chemical relations of odors, and their employment as tests. By *Geo. C. Schaeffer.*

On meteoric stones; with an account of some recently discovered. By Prof. *J. Lawrence Smith*, of Louisville, Ky.

On two new general methods of chemical analysis. By Dr. *Wolcott Gibbs.*

On the volumetric determination of Nitric, Arsenic, Antimonic and Stannic acids, and on the separation of Manganese, Cobalt and Nickel. By Dr. *Wolcott Gibbs.*

The American Patent System, and its relations to science—especially to chemical science. By Dr. *L. D. Gale*, of the Patent Office, Washington.

(5.) *Zoology.*

Life in its physical aspects. By *Charles Girard.*

On the Delphinus, or Phocena Orca, the Whale Killer or Thresher, mentioned by John Tradescant in the journal of his voyage to Russia in 1618. Communicated by Dr. *Hamel*, of the Imperial Academy of Sciences at St. Petersburgh.

Experimental observations on the sense of smell and taste. By Dr. *H. C. Hilgard.*

On the development of monocotyledonous stems. By *J. Darby*, of Georgia.

On the Whale. By Lieut. *Maury*, U. S. N.

Appendix.—On Personal Equation, &c. By *J. Winlock.*

Some reasons for suspecting the Mobilian language to have been spoken along the southeastern shores of North America in the first half of the 16th century. By *Buckingham Smith.*

2. *Abstract of a Meteorological Journal kept at Beloit College, Beloit, Wis., for the year* 1853, (communicated for this Journal.—Lat. 42° 30′ 23″ N.; Long. 12° 03′ 20″ W. from Washington; elevation above Lake Michigan, 172 feet—above the Ocean, 750 feet; by S. P. Lathrop, M.D., Professor of Chemistry and Natural History.

Months.	Barometer.			Thermometer.			Cloudiness.	Prevailing winds.	Inches rain & melted snow.
	Max.	Min.	Mean.	Max.	Min.	Mean			
January,	29·65	28·44	29·635	48	− 5	27·04	3·70	N., S. & S.W.	1·25
February,	29·61	28·66	29·193	50	− 9	23·00	4·55	N.W. & N.	2·85
March,	29·64	28·69	29·198	60	0	33·57	3·48	N.W., N. & S.	2·00
April,	29·56	28·58	29·147	70	27	40·12	4·82	N.E. & N.	5·68
May,	29·59	28·80	29·295	84	38	57·44	4·54	N.E., N.W. & S.	4·37
June,	29·53	28·92	29·377	91	54	73·16	3·04	S.W. & S.	4·85
July,	29·52	29·04	29·343	83	54	68·90	2·78	S.W & N.E.	8·10
August,	29·55	29·08	29·238	91	52	71·37	3·08	S.W. & N.W.	1·68
September,	29·53	28·78	29·234	91	41	64·02	3·97	S.E. & N.W.	6·48
October,	29·58	28·78	29·431	73	11	47·00	2·65	S., S.W. & N.	·50
November,	29·77	28·91	29·347	61	10	41·30	6·02	S.W. & N.	6·85
December,	29·59	28·53	29·156	53	− 5	26·39	3·83	S.W. & N.W.	1·10
Year.	29·77	28·44	29·308	91	− 9	47·75	3·87	S.W., N.W. & N.	45·71

The mean temperature of the past year is 47°·75, being nearly the mean of the three previous years, which is 47°·505.

The mean temperature for the winter months of 1852–53 is 24°·863, which is something over a degree less than the mean of the two previous years, and 2°·567 lower than for the year 1850–51. The mean temperature for the spring months is 43°·71, being nearly as low as the temperature of the same months in 1850, which was 43°·08, and 2° 713 lower than the mean of 1851 and 1852. The mean temperature of the summer months is 71°·143, being nearly the same as in the year 1850, and 1°·24 higher than the mean of the years 1850–52. The mean temperature of the autumnal months is 50°·773 being about the same as the year 1851, and 1°·38 above the mean of the years 1850–52.

The average density of the atmosphere as indicated by the barometer, is 29·308 inches, being ·031 inch below the year 1851, and nearly ·04 higher than either of the years 1850 and 1852.

The amount of rain and melted snow for the year is 45·91, which is 5·91 more than the previous year, and 7·66 less than the mean of the two years 1850–51. This was not so equally distributed through the several months of the year as usual, the month of July having 8·10 inches, while the month of October had only 0·50 inch. September and November have nearly the same amount.

The amount of snow which fell in the winter of 1852–53 is 30 inches, being the same amount as last year, and more than either of the two previous years, and it was quite equally distributed through the winter months.

The last year was never surpassed by more abundant crops. They were *uniformly* good. None of them were injured to any amount, by any unfavorable condition of weather, or superabundance of insects injurious to vegetation, or blight or mildew. Fruit trees of every kind and description were loaded to their utmost with delicious fruit. We fear that we shall seldom see the like of the past year in the quantity and quality of grains, and the richness and abundance of fruit.

The prevailing winds were Southwest and Northwest, instead of N. and N. W., as in the three previous years.

CALENDAR.—*February* 8th, Coldest day of the year, average of thermometer –3°; 28th, Dwarf Peony and Star of Bethlehem up.

March 7th, Auroral arch; 15th, Remarkable Parhelia at 3 P. M.; 17th, Tulips, first birds heard to sing, wild geese seen; 19th, Bluebirds, Blackbirds and Woodcock seen; 22d, Narcissus up, Robins seen; 24th, Larkspur up; 26th, Triton seen.

April 4th, Pulsatilla potens and Ranunculus fascicularis in flower, striped snake seen; 14th, Gooseberries in leaf; 16th, Missouri and black Currant in leaf, Cucullaria in flower; 17th, commenced gardening; 25th, Jonquil in blossom; 26th, Dwarf Iris in bloom, Turtles, Frogs and Toads seen.

May 2d, Missouri currant in flower; 4th, Plum in blossom; 5th, Cherry in blossom; 11th, Puccoon and Liverwort in flower; 12th, Baltimore Oriole and Turtle Dove seen; 13th, Uvalaria perfoliata in flower; 16th, Silphium trifoliatum, Greek Valerian, Blue Phlox, American Cowslip and Tulip in flower, burr and black Oak in leaf; 17th, Robinia hispida and Carya alba in leaf; 19th, Lilac and Cowslip in flower, corn planting; 21st, Trillium and Stramonium in flower; 22d, Blue eyed grass and Hypoxis erecta in flower; 25th, first really growing weather, cold hitherto; 28th, Mountain ash, Baptisia tinctoria, Creeping vetch and Potentilla in flower; 30th, Zizia and Aquilegia in flower.

June 2d, Vibernum opulus, Cinnamon rose, Arenaria laterifolia, and Pentalophus longiflorus in flower; 6th, Capsella bursapastoris, Cypripedium spectabile, Ranunculus aquatilis, Philadelphus coronarius and Hydrophyllum virginicum in flower; 9th, Philadelphus flava and Iris versicolor in flower; 18th, Campanulas, Lobelias and Rudbeckias in flower.

July 13th, Auroral arch and streamers.

August 11th, Hottest day, average of thermometer 85°·33; 23d, Comet first seen in the west at 8¾ P. M.

September 1st, Auroral arch.

October 25th, First snow.

3. *The Climate of San Francisco—Review of the Weather for the Year* 1853; by Dr. HENRY GIBBONS.—The first part of January was cloudy and rainy, but after the 11th, the weather was mostly clear and charming, only one rain occurring in the last two weeks. The lowest temperature was 41°, and the highest 62°. The mean at sunrise was 47½° and at noon 56½°. The prevailing winds were very light, from north and northwest. There were nine days entirely clear, and four days entirely cloudy. January 1852, was colder, having five mornings below 41°; January 1851, was much colder, having 13 mornings below that point. Both these months were dry, scarcely any rain falling. But the first two weeks of January 1852, were rainy; the remainder of the month dry. Sacramento City was drowned on the 1st of the month. In January 1851, there was ¾ inch of rain; in 1852, ½ inch; and in 1853, 4 inches.

February; for the first three weeks, the weather was fine. Up to the 21st there were no less than seventeen days entirely clear. In the last week there were four rainy days, but in the whole month only one day was entirely cloudy. The temperature was delightful, the means at sunrise and noon being 48° and 60°. The coldest morning 42°, and the warmest noon 67°. The prevailing winds were from north, northwest and west, and mostly light. The hills were covered with flowers. In February 1852, there were four mornings colder than in this month, and in 1851, thirteen colder mornings. February appears to be always a dry month. In 1851, there was ½ inch of rain; in 1852, ½ inch; in 1853, 1 inch.

March was mostly a pleasant month, with several moderate rains towards the middle, and three days of heavy rain in the last week. The prevailing winds were from West, Northwest and North, with an increasing tendency to West, and increasing force. The minimum temperature was 41°, and the maximum 77°; mean at sunrise 49½°, and at noon 62°. The first week of the month was very warm. On the 15th, Mount Diabolo was covered with snow, as mostly happens towards the end of March. There is commonly considerable rain in this month. In the dry winter of 1851, there were 2 inches; in 1852, 6½ inches; in 1853, 5 inches.

April was a pleasant month, with winds generally from West and Northwest, and frequent light sea breezes. Temperature agreeable, varying from 46° to 56° at sunrise, and from 59° to 75° at noon; means at sunrise and noon 52° and 65°. The heaviest rain for several years fell on the night of the 16th, viz: upwards of three inches in twelve hours. The only thunder of the season occurred during this rain. April mostly gives us some days of rainy weather. In 1851, an inch of rain fell; in 1852, only ¼ inch; in 1853, 5 inches. The coldest morning was 46°. In 1851, there were five colder mornings, and in 1852, eighteen. Dry and cold weather go together in our winters.

May was generally warm and pleasant, the coldest morning being 47° and the warmest 62°, while the coldest noon was 61° and the

warmest 81°. The means at sunrise and noon were 53½° and 68°. The wind settled in the western quarter, and increased in force, though not offensively high. There were several slight rains, with a large portion of cloudy and broken weather. The clouds always give their parting blessing in May. In 1851, there fell ¾ inch of rain; in 1852, ⅛ inch; and in 1853 ⅛ inch.

June was uncommonly warm, the mercury ranging from 49° to 60° at sunrise, and from 60° to 84° at noon. The sea winds were constant, but not often fraught with mist. The sky was unusually clear for summer.

The weather of July was uniform, varying in temperature at sunrise from 50° to 55°, and at noon from 63° to 78°. The means at sunrise and noon were 52½° and 68°. Cloudy and misty weather prevailed and there were but four days of clear sky from sunrise to sunset.

August was a cloudy and misty month, but less so than July. Its temperature also was very uniform, ranging at sunrise from 51° to 56°, and at noon from 63° to 76°. The means at sunrise and noon were 53° and 67°. The sea winds, though constant, were not often high.

In the three summer months of 1851, there were four misty mornings, and 33 misty evenings; in 1852, 7 mornings and 27 evenings, and in 1853, 15 mornings and 36 evenings, misty.

September was rather pleasant, affording one or two days really hot. The morning extremes were 50° and 60°, and the noon extremes 63° and 88°. The sea winds continued their daily visits with diminished force, and there was much cloudy and broken weather, with two small rains near the middle of the month. The means at sunrise and noon were 55° and 70°. September usually brings a day or two of light rain. One inch fell in 1851, a few drops only in 1852, and an eighth of an inch in 1853.

October was as usual, warmer than several of the previous months. The coldest morning was 49°, and the warmest 64°; the coldest noon, 60°, and the warmest 85°. The means at sunrise and noon were 54¼° and 71°. During this month, the sea winds began to give out. The sky was was generally fair, and one slight rain fell, amounting to $\frac{1}{10}$ inch. In October, 1851, there was $\frac{2}{10}$ inch, and in 1852, ¾ inch.

November placed the usual embargo on the sea winds. The temperature was moderate, a few slight frosts occurring. The coldest morning was 44°, and the warmest 59°; the coldest noon 55°, and the warmest 73°. The means at sunrise and noon were 51° and 63°. There was much cloudy weather, with occasional moderate rains. The prevailing winds were from west and south. The first southeasterly storm, in 1851, was on the 8th; in 1852, on the 13th; and in 1853, on the 16th. Quantity of rain in the three years respectively, 2 inches, 5½ inches, and 1½ inches.

December was more pleasant than common. The coldest morning was 40°, and the warmest 54°; the coldest noon 50°, and the warmest 69°. The means at sunrise and noon were 46½° and 57½. Hoar frosts were frequent, but the cold was not sufficient to injure vegetation. There was much fair weather. A copious rain fell on the 10th, and several light rains at other times. Prevailing winds from north, northwest, northeast and south. Thunder was heard on the 10th, for the

second time in the year. In December 1850, there fell 1 inch of rain; in 1851, 7 inches; in 1852, 12 inches—the greatest quantity in any one month for three years and more; in 1853, 2 inches.

The summing up for the year 1853 exhibits a mean temperature of 51½° at sunrise, and 65° at noon, which is warmer by two degrees than either 1851 or 1852. The lowest mark reached by the mercury was 40°, or eight degrees above the freezing point. The extreme of heat was 88°. In 1852, the extremes were 35° and 98°; in 1851, 30° and 84°; and in December 1850, the thermometer fell as low as 28°. The amount of rain in each month of 1853, was, in round numbers, as follows: January, on eight days, 4 inches; February, four days, 1 inch; March, six days, 5 inches; April, eight days, 5 inches; May, three days, ⅛ inch; June, July and August, none; September, two days, ⅛ inch; October, one day, $\frac{1}{10}$ inch; November, eight days, 1½ inches; December, six days, 2 inches; making in the year, forty-four days on which rain fell, to the depth of 19 inches. In 1851, there was rain on fifty-three days, quantity 15 inches; in 1852, on sixty days, quantity 25½ inches. From the 1st of January, 1853, to the dry season, the quantity was 16½ inches; and from the dry season to the end of the year, 3½ inches. The last rain of the Spring was May 24th, and the first of the Autumn was September 15th. The hills began to look green in the last week of November, and at the close of the year at least thirty species of plants were in bloom around the city, some of them the lingering flowers of Summer, and a few the products of a new growth. There were two small specimens of thunder during the year, none of the aurora borealis, and a considerable sprinkling of meteors in the second week of August, and also in the fourth week of November.

4. *Mammoth Trees of California.*—An article in the Sonora Herald of August 27, 1853, contains the following statements respecting the Mammoth Trees of California, one of which was the subject of Prof. Gray's remarks in the last volume of this Journal. The tree that has been cut down was 95 feet in circumference at the ground, and 300 feet high. Another tree is lying near by, now dead. It is decayed within, and contains a cavity which for 250 feet of its length averages 10 or 12 feet in height; so that a man may enter it on horseback and ride the whole distance. From its diameter near its base, its circumference was estimated at 110 feet, and it was judged to have been near 400 feet high. Another tree still standing has a circumference near the ground of 97 feet, its height 350 feet. Not far distant there is a trio of trees, the united circumference 92 feet, and height 300, the middle one rising 200 feet without a branch. In the same neighborhood there is a twin tree, with a circumference of 90 feet; the trunks of the two parts are joined for 10 feet; the height is 325 feet. A single tree of perfect symmetry, is 92 feet in circumference and 350 feet high. There are 85 of these mammoth trees scattered over an area of 50 acres. The soil of this Mammoth Grove is moist and rich.

On the route from Sonora to the Grove, about 10 miles northward of Sonora, there are the "Natural Bridges" over the Cayote Creek, four miles below Vallecita. The rock is limestone. The entrance of the arch under the upper bridge is 25 feet wide and 30 feet high, and the

rock is variously eroded into Gothic forms and hung with stalactites. The lower bridge is of equal extent, though differing in imitating more the rounded Grecian style, than the Gothic, in its arches.

Fifteen miles north of Vallecita is Murphy's camp, and 15 miles beyond, the traveller arrives at the Mammoth Grove. Four miles before reaching it, he has the Sierra Nevada in view, bounding the horizon on the north and east, high hills between the Sugar-pine and Tuolumne on the southeast, Bald Mountain on the south, and the Bear Mountain range on the west; and the country is a mass of precipitous hills and deep recesses or shaded ravines. Nine miles north of Murphy's there is an extensive cave with many apartments.

5. *Recent Earthquake Shocks in California*, (from letters of W. P. Blake, dated San Francisco, and addressed to one of the editors.)—A slight shock of an earthquake was felt in this city by many persons on the morning of March 2d. I was sleeping with my head towards the east, and my couch seemed to have received a violent push from that direction; the windows and doors rattled at the same time. Although I had never before experienced the sensation of an earthquake, I was so strongly convinced that I had been awakened by one, that I arose and carefully noted the time (4^h 40^m A. M.). A friend who occupies a room near mine, and was lying north and south, felt the movement, and describes it as transverse to the direction of his bed. The motion was evidently very rapid, but not sufficiently extensive or violent to leave any traces of its passage.

A similar shock was felt here in January last, at 3 o'clock on the morning of the 9th. And on the third of the same month, two successive shocks were reported at Mariposa. The last steamer that arrived from Rejou, brought the intelligence that clouds of smoke and ashes were constantly rising from the crater of Mount St. Helens. It is said that the smoke issues in sudden puffs.

Earthquakes are so common all along this coast, that it becomes important to have at different points suitable instruments for recording the direction and intensity of the waves.

Another earthquake was felt in this city on the 10th of April, at 10^h 38^m A. M. It was very generally felt throughout the city. It is also stated that it was so violent at Point Lobos that glass in some of the windows was broken by the jar. The motion of the earth appeared to be in a vertical rather than a horizontal direction, producing a sensation of rising and sinking, as if a heavy body had fallen upon an elastic floor. The vibrations were short and sharp, apparently as if formed by an explosion. Two shocks were noticed, with an interval of five or six seconds between them.

6. *Memorial to the United States Congress by a Special Committee of the American Association for the Advancement of Science, on establishing a Geographical Department of the Library of Congress.*

At the meeting of the American Association for the Advancement of Science, held at Cleveland during August, 1853, a resolution was submitted providing for a special committee to prepare and present a Memorial urging on Congress "the advantages of establishing a complete, thoroughly organized, and liberally sustained Geographical Department of the Congress Library, and presenting therein such a project or plan

of organizing this Department as shall seem to the Committee best adapted to promote its final usefulness and success in relation both to the Government and to the country at large." The undersigned members of this Committee, in execution of the duty thus imposed, would now respectfully offer such views on this subject as seem most appropriate.

I. There is not in the United States, or on this continent a single collection of geographical materials which is even tolerably complete. The Harvard collection, the collection of the State Department, the Hydrographic Office, the Topographical and Engineer Bureaus, the Coast Survey, the Smithsonian Institution, and those of Libraries, Colleges, Societies and scholars generally, throughout our country, have been formed for some special and limited purpose, and hence, all are practical and imperfect. None rises to the rank of a true Geographical Library, in which should be found the means of investigating all geographical questions, both of sea and land, at home and abroad. Year by year partial localities assume the highest temporary importance; as for instance, quite recently, Hungary, the Black Sea, Japan, China, Australia, the Pacific Islands, Central America, our entire western coast, the Amazon, the La Plata, and especially our unexplored Western Territories. None can say how great the value of local information on any country, either old or new, may become in a single year. Yet, there is not on this continent any single place where we can resort with confidence for the materials requisite for precise and complete investigation on such questions, as they arise. Publications have actually been made which amply illustrate most great questions of Commerce, policy, international relations, military operations, and Science, so far as they depend on Geography; but these publications have only been systematically collected in some of the great libraries of the European capitals. Hence, we are forced to seek across the Atlantic, the means of thorough investigation into many of the important questions influenced by geographical considerations, or unquestioningly to accept the information vouchsafed by foreign investigators, by whatever prejudices or designs their views may be affected. For instance, would we follow critically the military operations between Turkey and Russia: there are not to be found in this country the geographical aids requisite for a strategic insight into the present and coming campaigns. In the French *Dépôt de la Guerre*, on the contrary, we would be able to trace each step and probability, because the French Government has been systematically collecting, through many years, all possible information on this, as on all other supposable theatres of war or policy. It is a singular and striking fact that the most extensive collection of maps now in America, even in the American department was collected by Prof. EBELING of Hamburg, and that this collection, purchased by Mr. Thorndike of Boston, and by him presented to the Harvard Library, has been laid under serious contribution for some of our most important negotiations, especially that on the Northeastern Boundary question. Not only is there among us a signal deficiency of collections on foreign geography, but there is at best only a most imperfect and fragmentary centralization of materials illustrating the past and present geography of the states, counties, towns, cities and historical localities of the Uni-

ted States. In brief, while there are sundry partial and special collections of great value owned by scholars, societies, and the General and State Governments, there is nowhere a real and general library of Geography in the United States. Hence we consider the formation of a systematic, comprehensive and complete geographical library, as a most genuine and unequivocal *American desideratum.*

II. The materials which an American National Library of Geography should embrace may be distributed under the following classes:—1st, United States Maps, including general, state, county, town, city and village maps, and plans of historical localities; embracing not only published maps, but manuscripts or tracings of valuable unpublished surveys. 2d, United States Charts, including DES BARRE's and other early surveys, the surveys of our coast, rivers and harbors by the Engineer and Topographical Bureaus, and the coast survey, the topographical lake survey, and all municipal and private charts of importance along our entire seaboard, as BLUNT's, for instance. 3d, Foreign Maps, including the detailed Topographical Maps prepared by the several European States, such as those made by the Ordnance, French, Swiss, German, Prussian, Italian, Austrian, Russian, Swedish, Hindostan, Canadian and Cuban Surveys. Also all maps of the West Indies, of Central and South America, of the British Provinces, (including Hudson's Bay Company Maps,) the Russian Possessions, the Pacific Islands, and, indeed, *all* valuable maps of foreign domains, whether of public or private origin. 4th, Foreign and Ocean Charts, including the 2,000 British Admiralty Charts, the 1,400 charts of the French *Dépôt de la Marine*, the Spanish, Prussian, and Swedish charts, the great variety of private and Expedition charts, MAURY's wind and current charts, &c. 5th, The publications of Exploring Expeditions—especially the works of the British, French, Russian, Austrian, Spanish, and American Governmental Expeditions; as also reports of private voyages and travels of reputation. Peculiar importance should be attached to publications illustrating the early discoveries and explorations of the American continent; to subsequent explorations of our coast and interior, and the Polar, Central and South American voyages and travels. 6th, Geographical Society publications and periodicals, such as those of the Royal Geographical Society, of London; the Bombay Geographical Society; the Asiatic Researches; the Paris *Société de Géographie;* and the Russian Geographical Society; with the *Nautical Magazine*, and other similar periodicals. Also, all pamphlets on geograpical subjects should be collected with especial industry and care. 7th, Books illustrating local geography—especially within the United States; topographical descriptions; hand-books, town and city annals, and whatever can illustrate our geography in relation to history, should be collected; and the same to some extent for foreign countries. 8th, Books and maps on Physical Geography. 9th, Special atlases of cities and states —such as those of VAN DER MAELEN, JOHNSON, the Society for the Diffusion of Useful Knowledge, COLTON, &c. BAUERKELLER's series of maps in relief should be added. 10th, Works on Geodesy and Navigation, and descriptions of geodetic surveys. 11th, Works on Geographical Bibliography. 12th, A pair of first-class terrestrial and celestial globes.

It is only by great industry and skill in collecting these materials that a geographical library of the first order can be formed at all, and even then completeness can be obtained only after some years of vigorous and liberally sustained effort. The Library of the *Dépôt de la Marine* for instance, includes over 4,000 distinct works of geography, many of which extend to several volumes; besides which there is a vast collection of separate maps and charts. Such a repository can be formed only by collecting through a long series of years; though that portion which is of the greatest immediate importance, can fortunately be accumulated in a comparatively short period.

III. * * *

A Geographical Library of Congress would possess an important advantage in that prestige of name and position which would enable it to enlist, if well administered, the friendly cooperation of foreign representatives, and through them of the proper departments of their respective governments. As many of the most important geographical works have been official or governmental publications, this cooperation is actually essential to the completion of such a collection as that proposed.

A geographical library of Congress would furnish invaluable aid to the coordinate executive branches of Government, and would be a judicious and well-requited enterprise, were it only for the services it would render to the State Department, the Engineer and Topographical Bureaus, the Coast Survey, and the various Naval Bureaus. Its value in relation to river and harbor improvements, to local and general American history, to map compilations for Government and common use, to the intelligent discussion by the periodical press of important pending questions; its agency in fostering and giving a right direction to contemplated explorations, in making known the researches of foreign explorers, and in indicating what geographical researches are most essential or most worthy of patronage; these and many other prospective uses might be urged as reasons why the general government should execute this project for the benefit and in behalf of this nation.

IV. A geographical library can be formed and duly administered only by being placed under the special direction of one versed in geography as a science. In this respect it differs much from any other section of a general library. The materials to be accumulated must be procured from sources so diverse and special, that a general geographer cannot be well informed thereon. Many valuable maps and charts exist only in manuscript, and tracings should be procured and verified. This demands an acquaintance with drawing. An active and laborious correspondence would be necessary to bring together the vast number of local maps which are or will be published on the subdivisions of the United States; also the best foreign maps of cities, provinces, &c. Nor can any one but a geographer of superior capacity, attain that critical knowledge of the character and reliability of different maps and charts, which is the first essential before using them. The system to be employed in storing, arranging and indexing an aggregate of many thousand maps and charts, differs entirely from that pursued in book libraries. The charge of compiling new maps and of tracing copies for the library and for individuals, which would be cardinal features in such a library, is totally foreign to the sphere of a general librarian.

It would be incumbent on the head of this department to maintain correspondence with Geographical Societies, with explorers, and with map publishers, all of which could be done only by a geographer. Moreover, it would be highly desirable that an annual report on the progress of geographical discovery and science should be submitted to Congress for the benefit of all who are interested in this important branch. All care should be exercised in procuring prompt information on such dawning and passing events as involve geographical elements, by corresponding with well informed authorities, by collecting and studying the publications bearing thereon, and by maintaining a complete reference index in as perfect a condition as practicable.

In view of all these facts and considerations, it is evident that the Geographical Department now proposed should have special rooms, a special head, special employés, and a special administration. As a section of the general library, it could by no means be well conducted, for no general librarian living could successfully discharge special duties of the nature proposed. A distinct and coordinate organization and administration seem therefore indispensable to success. Moreover, stability of tenure for the geographical librarian and his assistants, serving as it would to perpetuate the teachings of experience, should be secured and esteemed next only to character, mental vigor, industry, method and capacity for administration. Under the general direction and control of the Joint Library Committee, a geographical section thus organized could soon be made, it is believed, an efficient auxiliary to the great interests of legislation, of commerce and of science.

V. The appropriations which this department would require during the first two or three years, would much exceed those for subsequent years, as they would be chiefly absorbed in the purchase of those geographical publications which are at once procurable. The 2,000 Admiralty charts, the 1,400 French charts, the English, Irish, French, German, Prussian, &c. surveys, the principal atlases, the English, French, Russian, Spanish, American, and other volumes of explorations, the geodetic and nautical works, the gazetteers, encyclopedias, hand-books, &c., the globes, and many other items, should be procured almost at once. For the first year an appropriation of $30,000 appears to be no more than a judicious and efficient beginning would require. For the second and third years, a less amount would suffice, and then the requisite appropriation would but slightly exceed that needed for administration, and for the purchase of the special publications of the year. A languishing and feeble beginning is peculiarly to be deprecated, and a large part of the materials now published can better be procured and made available at once than by delaying through a long term of years. The proposed collection is needed *now*, and every year that is lost will add to the difficulty of completing the portion relating to our early history.

In concluding this memorial, we would respectfully state that the project now advocated is one which can scarcely fail to commend itself to all enlightened minds. Acting as we now do in the name and in behalf of an Association embracing a large portion of the American cultivators of science, we esteem it fortunate that the interests of this Association, of Congress, and of the entire nation, are so harmonious and

even identical on the subject of this memorial. It is, therefore, with gratification and with hopeful confidence that we now commend to the liberality of Congress a project which we believe to be truly advantageous to all and injurious to none.

Respectfully submitted on behalf of the American Association for the Advancement of Science, by A. D. BACHE, J. J. ABERT, J. G. TOTTEN, A. GUYOT, M. F. MAURY, PETER FORCE, CHARLES HENRY DAVIS, E. B. HUNT.

7. *On Gold and Platinum of Cape Blanco;* by W. P. BLAKE, (from edit. corresp.)—I have recently procured a sample of the Platinum and Gold washed out from the beach sands at and near Point Oxford (Cape Blanco) on the California coast, near lat. 43° N.

The gold is in small and very thin scales. About 20 per cent. of the sample consists of platinum, also in minute round scales not much larger than grains of common writing-sand. These scales are readily lifted by a magnet, but are not easily separated from the gold. I am informed that the miners throw out as much of the platinum as possible, as it lessens the value of the gold in the San Francisco market. The amount of platinum in the gold as washed out is estimated to vary from 10 to 30 per cent.

8. *Supposed Corallines of the Colorado Desert.*—The supposed corallines observed by Mr. Blake on the borders of the region of the Ancient Lake in the Colorado Desert, are, as he suggests in a recent letter, and as we find on examining his specimens, calcareous incrustations or tufa having singular coral-like forms, resembling some Nullipores.—D.

9. *Additions to Article on Chinese and Aztec Plumagery;* by D. J. MACGOWAN.—The two popular encyclopedias, referred to on page 59, are the Keh chi king yuen, and the Yuen kien lui yen.

A beautiful article from Shensi is sometimes met with, called *kung tsióh* [peacock] jacket pieces, composed of the skin and feathers covering the head of a species of Pavonidæ, probably the *Polyplectron Tibetanus* of Gmelin and Brisson. Each piece contains about sixteen square feet, and is consequently the covering of many peacocks' heads. Yet they can be had for ten or twelve dollars. The gorgeous garments made out of these feathered skins being less warm than fur, are mostly sought by gay and wealthy ladies, by whom they are worn within doors. The prevailing tints are green and blue, of resplendent metallic lustre; these colors are of varying intensity, mutually changing into each other, or shotted according as the light falls upon them in different directions. Were not the feather garments of the Aztecs made wholly or chiefly like these, of both skins and feathers?

10. *Prof. Edward Forbes.*—Prof. Forbes has been appointed to the vacant chair of Natural History in the University of Edinburgh.

11. *Brazil.*—The eminent Botanist, Martius, has announced his intention of publishing in his general Flora of Brazil a map showing the routes of the most distinguished travellers who have visited that country, and another map giving a general view of its geognostical features.

12. *Obituary.*—ROBERT JAMESON.—Prof. Jameson died in April last at Edinburgh, in his 81st year. He was born at Leith, in 1773. He was for two years a student under Werner at Freyburg, and continued

ever afterward an ardent advocate of the views of his master. Returning from Freyburg in 1804, he was appointed Regius Professor of Natural History in the University of Edinburgh, Lecturer on Mineralogy, and Keeper of the Museum. In 1798, he published on the Mineralogy of the Shetland Isles and the islands of Canary; in 1800, appeared his "Outlines of the Mineralogy of the Scottish Isles;" in 1808 his "System of Mineralogy." In 1819 he commenced in connection with Dr. (now Sir David) Brewster the publication of the Edinburgh Philosophical Journal, after the 10th volume of which he became the sole editor. Prof. Jameson also published various memoirs, and largely promoted the progress of Science by his labors and influence.

13. *Elementary Geology;* by EDWARD HITCHCOCK, D.D., LL.D., Pres. Amherst Coll. and Prof. Nat. Theol. and Geol. New edition, revised, enlarged and adapted to the present state of the Science. 418 pp. 12mo, with numerous illustrations.—This work is too well and favorably known to require a detailed notice in this place. It has already reached its twenty-fifth edition. In preparing for this new issue, large additions were made from the stores of facts gathered by laborers in the Science in different countries, besides more than eighty new wood-cut illustrations. The chapter on the operation of aqueous agencies in effecting Geological changes has been entirely re-written, and the author has embodied the results of his own valuable researches on river Terraces and Drift through the New England states and elsewhere. The size and character of the work are especially adapted to class instruction.

14. *Archives de Physiologie de Therapeutique et d'Hygiène*, sous la direction de M. BOUCHARDAT, Prof. d'hygiène à la Faculté de Médecine de Paris. No. 1, Janvier, 1854. Mémoire sur la Digitaline et la Digitale par E. HOMOLLE et T. A. QUEVENNE. Paris, Germer Bailliere.—This first number of the Archives, extending to 376 pp. 8vo, is occupied with the elaborate memoir of MM. Homolle and Quevenne on Digitaline.

15. *Lectures on Histology*, delivered at the Royal College of Surgeons of England in the session 1851–52, by JOHN QUEKETT, Resident Conservator of the Mus. Roy. Coll. Surgeons of England and Professor of Histology. Vol. II, Structure of the Skeleton of Plants and Invertebrate Animals. 413 pp. 8vo, with 264 wood-cuts. London, 1854. H. Bailliere.—These lectures treat in a popular way, and in some departments with considerable detail, of the structure of invertebrate animals. The work commences with Sponges, and passes then to the Diatomaceæ, Polythalamia, Zoophytes, Echinodermata, Echini, Mollusca, and Annulata.

16. *Illustrations of the Birds of California, Texas, Oregon, British and Russian America*, intended to contain descriptions and figures of all North American birds not given by former American authors, and a General Synopsis of North American Ornithology, by JOHN CASSIN. Philadelphia, Lippincott, Grambo & Co.—No. 3 of this valuable and beautiful work completes to the 96th page. It contains descriptions of Kirtland's Owl (Nyctale Kirtlandiæ), Blanding's Finch (Embernagra Blandingiana), the American House-Finch (Carpodacus familiaris), the Long-tailed Chickadee (Parus septentrionalis), the Red-breasted Teal

(Querquedula cyanoptera), with general observations on the Falconidæ. The plates, of which there are five, are faithfully drawn, and well colored. No. 4 has also appeared, and continues the subject of the Falconidæ. This work is to be completed in 30 parts, each part to contain five plates, and the whole to form two large octavo volumes when completed. Price $1, each part.

17. *Astronomical Observations, made under the direction of* M. F. MAURY, *Lieut. U. S. Navy, during the year* 1847, *at the National Observatory, Washington.* Vol. III. Published by authority of the Secretary of the Navy. 4to. Washington, 1853.—Besides the tables of observations made at the National Observatory, this volume contains as appendix A, Observations on Solar Spots made at the Observatory of Georgetown College from Sept. 20, to Nov. 6, 1850, by Prof. B. Sestini, S. J., illustrated by 44 plates: Appendix B. Observations on the Mississippi River at Memphis, Tenn., by R. A. Marr, U.S.N.; in which it is stated that the mean temperature of the river is 60°·95 F., while that of the atmosphere is 60°·44; that the quantity of water passing Memphis per day in March, 1850, varied between 46,138,127,330 cubic feet and 88,827,520,040, the river being 76 to 83 feet deep, and in October, from 10,708,228,080 cubic feet to 16,892,279,100, the least at the close of the month, and the depth of water 52·2 to 56 feet. The silt collected in the river at this time was sent to Ehrenberg, and the Appendix on this subject closes with a Report on the species of infusoria it contained. The whole number of forms observed was 88; and out of 44 polygastrica, no new species were detected excepting a doubtful Gloconema. The high water sediment afforded 65 species, the low water 54. Ehrenberg adds:

"According to my direct investigations, the microscopic organic living part of the river mud, amounts to—

In the Ganges ($\frac{1}{8}$—$\frac{1}{4}$),	corresponding	in	each	second	to	69—	139	cub.	ft.
Nile ($\frac{1}{20}$—$\frac{1}{10}$),	"	"	"	"	"	6—	13	"	"
Mississippi ($\frac{1}{50}$—$\frac{1}{33}$),	"	"	"	"	"	2—	4	"	"

"The last is evidently too small and will probably be modified by examination of the finer mud out of the current and near the shore."

The Ganges at high water carries in one second 580,000 cubic feet of water, the Nile 176,148 cubic feet, and according to the data of Marr's tables, the Mississippi carries on an average 434,711 cubic feet.

18. *Field-Book for Railroad Engineers;* containing Formulæ for laying out curves, determining Frog Angles, Levelling, Calculating Earthwork, etc., together with Tables of Radii, Ordinates, Deflections, Long Chords, Magnetic variation, Logarithms, Logarithmic and Natural Sines, Tangents, etc.; by JOHN B. HENCK, A.M., Civil Engineer. 244 pp. 12mo. New York, 1854. D. Appleton & Co.—A valuable pocket companion for the practical engineer. It is neatly printed, and put up in pocket-book style, is of convenient size, and in its contents just what a book for the purpose should be.

19. *Annual Report of the Superintendent of the U. S. Coast Survey,* showing the progress of that work during the year 1852. 174 pp. 4to, with numerous charts. Washington, 1853.—The Annual Report of Prof. Bache is one of the most valuable documents issued annually by Congress, and we rejoice to see the volume improved in quality of pa-

per and printing. The plates, which are of great value, now appear in a form convenient for consultation and preservation.

J. Müller: Über den allgemeinen Plan in der Entwickelung der Echinodermen. 42 pp. 4to, with 8 plates. Berlin, 1853. From the Trans. of the Königl. Akad. der Wissensch. zu Berlin.

Alexander von Humboldt: Kleinere Schriften von A. von Humboldt. Erster Band; Geognostiche und physikalische Erinnerungen, with an atlas containing a view of the volcanoes of the Cordilleras of Quito and Mexico. Stuttgart and Tubingen. 1853. T. G. Cotta.

Carl Vogt: Lehrbuch der Geologie und Petrefactenkunde. 2d edition, in 2 vols. 1st vol. just issued. Bräunschweig, 1854.—An excellent work of unusual beauty in its illustrations.

R. Ludwig: Das Wachsen der Steine oder die Krafte welche die Bildung und Entwickelung der Gebirgsarten vermitteln. 226 pp. 8vo. Darmstadt, 1853.

Adolf Kenngott: Krystallformennetze zum Aufertigen von Krystallmodellen. 2d edition. Vienna, 1854.—This very cheap work is a series of plates containing figures for the construction of models of crystals. The outline of the faces of various crystalline forms is given, and they are so arranged that it is only necessary to cut out the figures from the plates and bend the planes into their places, to make the model; and if the sheets of figures are first pasted on Bristol board, the models will have all the firmness and durability desired.

William Parker Foulke: Discourse in Commemoration of the Founding of the Academy of Natural Sciences of Philadelphia, Delivered March 20, 1854. 58 pp. 8vo. *Philadelphia*, 1854.

A. Davis (Cor. Mem. N. Y. Hist. Soc., &c.): History of New Amsterdam, or New York as it was in the days of the Dutch Governors, together with papers on Events connected with the American Revolution and on Philadelphia in the Times of William Penn. 240 pp. 16mo. *New York*, 1854. R. T. Young.

The American Medical Monthly, Edward H. Parker, M.D., Editor. Vol. I, No. 4, April, 1854. *New York.* G. P. Putnam & Co.—Issued in monthly numbers of 80 pages each. Single copies 25 cts. each.

People's Journal, Alfred E. Beach, Editor. No. 86 Nassau st., New York. Vol. I, No. 6, April, 1854. One dollar a year.—A popular and well illustrated monthly of 32 small quarto pages, treating of the popular or useful arts, with horticulture, agriculture, and whatever is of interest to the farmer, etc. etc.

The Practical Mechanics Journal, Vol. VII, No. 1, May 1854. In monthly numbers of 24 pp. 4to. 25 cts each. *London* and *Glasgow*, W. & J. H. Johnson. *New York*, Stringer & Townsend, 222 Broadway.—A work of real value to the mechanic, able and thorough in its papers, excellent and full in its illustrations. It gives new processes and inventions in chemical arts as well as in manufactures, and also discriminating notices of new publications.

The Merchant's and Banker's Almanac for 1854—published by J. Smith Homans, No. 70 Wall street, New York—contains the Calendar—List of Banks—Banking Directory—Banking Laws, &c. &c.

Proceedings of the Boston Soc. Nat. Hist.—Jan., 1854.—p. 309. On the reproduction of lost parts in Reptiles; *W. I. Burnett.*—p. 311. On Rattle-snakes; *Ib.*—p. 316. On the Cotton worm of the Southern States; *Ib.*—p. 323. On the Sedative action of the poison of the Rattle-snake; *Ib.*—p. 324. List of Birds found both in Europe and America; *T. M. Brewer.*—p. 331. On the zoological nature of Infusoria; *W. I. Burnett.*—p. 353. On a remarkable case of bisexual hermaphroditism; *Ib.*—p. 368. On the nature and character of muscular tissue; *Ib.*—p. 371. On the development of Mollusks in Holothuridæ; *Ib.*—p. 377. Note on the relations of the Fossil elephant of Europe and America; *J. Wyman.*—p. 378. On Fos-

sil footmarks; *E. Hitchcock.*—On the development of viviparous Aphides; *W. I. Burnett.*

Proceedings Acad. Nat. Sci. Philadelphia, Vol. VII, No. 2.—p. 24. Descriptions of new species of Fishes collected in Texas, New Mexico and Sonora; by *S. F. Baird* and *C. Girard.*—p. 29. Rectification of the Generic names of Tertiary Fossil Shells; *T. A. Conrad.*—p. 31. Notes on Shells and descriptions of three recent and one Fossil species; *T. A. Conrad.*—p. 32. Note on the genus Amblychila, Say; *J. L. Le Conte*, (with a plate.)—p. 35. Synopsis of the Species of Platynus and allied genera, inhabiting the United States; *J. L. Le Conte.*—p. 59. Descriptions of new genera and species of North American Frogs; *S. F. Baird.*—p. 62. On Fossil Coniferous wood, from Prince Edward's Island; *J. W. Dawson.*—p. 64. Description of a species of Crane found in Wisconsin; *W. Dudley.*—p 64, 66. Description of Fossil Trees in the coal rocks near Greensburgh, Westmoreland Co., Pa., and fossil fruit, in those of Beaver Co.; *A. T. King.*—p. 66. Descriptions of new Birds of Northern Mexico; *D. N. Couch.*

Proceedings of the American Academy of Arts and Sciences. Boston. Vol. III.—p. 11. On inhaling a fusel-oil compound; *J. Wyman.*—p. 12. On the formation and function of the Allantois; *W. I. Burnett.*—p. 17. On cartilaginous and osseous tissues; *Ib.*—p. 25. On the internal structure of the cranium of the Mastodon.—p. 42. Observations on the family of Cyprinodonts; *L. Agassiz.*—p. 43. On the Signification of Cell-segmentation and the relations of this process to the phenomena of Reproduction; *W. I. Burnett.*—p. 48. Characters of some new genera of Plants, mostly from Polynesia; *A. Gray.*—p. 55. On the development of Aphides; *W. I. Burnett.*—p. 63. Observations on some new species of Cartilaginous fishes; *L. Agassiz.*—p. 65. On a new living Cestracion; *Ib.*—p. 68. Coal region of Deep River, North Carolina; *C. T. Jackson.*—p. 70. On a new filtering apparatus; *J. P. Cooke.*—p. 73. Notices of new species of Mosses from the Pacific islands; *W. S. Sullivant.*—p. 85. On the crystalline form of Arsenic; *J. P. Cooke.*—p. 89. Observations on the Torpedo occidentalis; *J. Wyman.*—On a modification of Ritchie's photometer; *A. A. Hayes.*—p. 94. Observations on a large California Coniferous tree; *A. Gray.*

Journal of the Academy of Natural Sciences of Philadelphia. Second Series, Vol. II, Part IV.

Art. XXVII.—Exotic Fungi from the Schweinitzian Herbarium, principally from Surinam; revised by Rev. *M. J. Berkeley* and *M. A. Curtis*, D.D.

XXVIII.—Descriptions of new species of Unio; by *T. A. Conrad.*

XXIX.—On some new Reptiles from Oregon and the Western Coast of Africa; by *E. Hallowell.*

XXX.—Embryonic Development of Planocera elliptica; *C. Girard.*

XXXI.—On Bathygnathus borealis, an extinct Saurian of the New Red Sandstone of Prince Edward's Island.

XXXII.—Monograph of the Genus Argonauta, Linn., with descriptions of five new species; by *T. A. Conrad.*

XXXIII.—Synopsis of the genera Parapholas and Penicilla; by *T. A. Conrad.*

Annals of the Lyceum of Natural History of New York.—Vol. VI, Nos. 2–4. 1854.

VIII.—On the Homœomorphism of Mineral Species of the Trimetric System; by *James D. Dana.*

IX.—Descriptions of three new species of Pisidium; by *Temple Prime.*

X.—On the Identity of Cyclas elegans, Ad. with Cyclas rhomboidea, Say.

XI.—Catalogue of the Terrestrial and Fluviatile Shells of St. Thomas, W. I.; by *R. J. Shuttleworth.*

XII.—Note on the Geographical Distribution of the Terrestrial Mollusks which inhabit the island of St. Thomas, W. I.; by *T. Bland.*

XIII.—On the Absorption of Parts of the Internal Structure of their shells by the animals of Stoastoma, Lucidella, Trochatella, Helicina, and Proserpina; by *T. Bland.*

XIV.—On Proserpina opalina Ad. and Helix Proserpinula, Pfr.; by *T. Bland.*

XV.—Description of a new species of bird of the genus Larus, Linn.; by *Geo. N. Lawrence.*

XVI.—Descriptions of new Fluviatile Shells of the genus Melania, Lam., from the Western States of North America; by *John G. Anthony.*

XVII.—Descriptions of new species of Shells; by *John H. Redfield.*

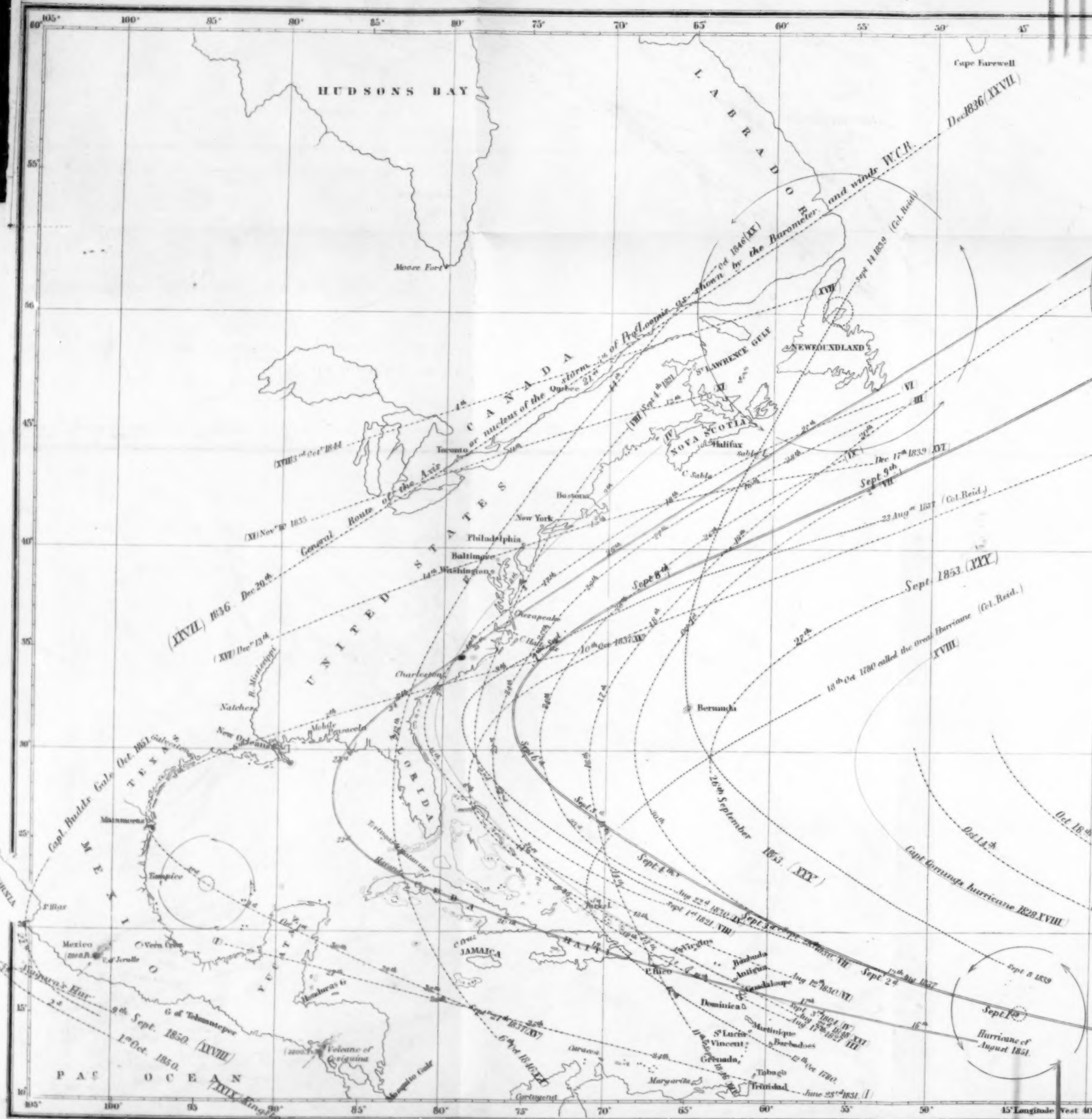
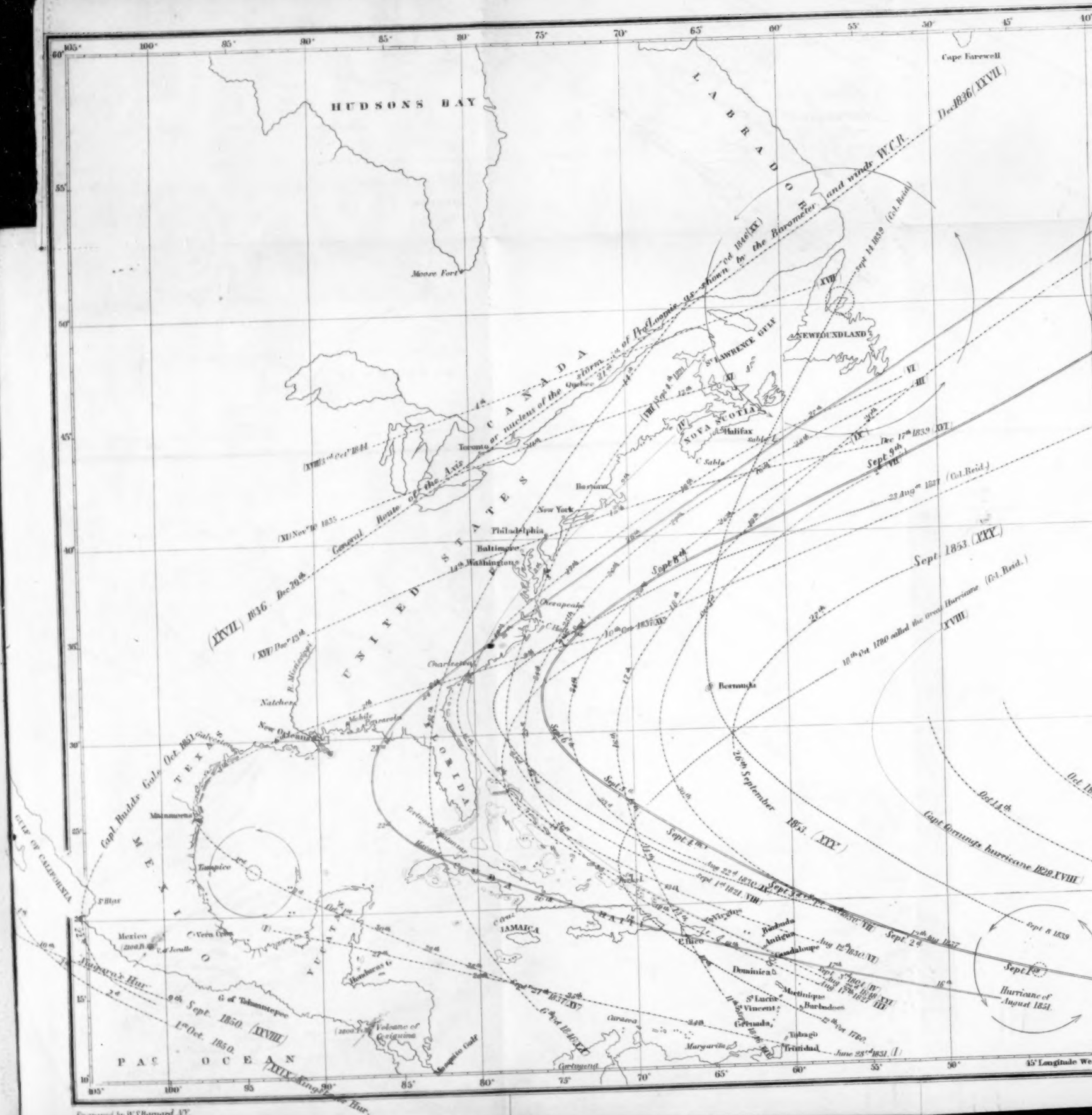
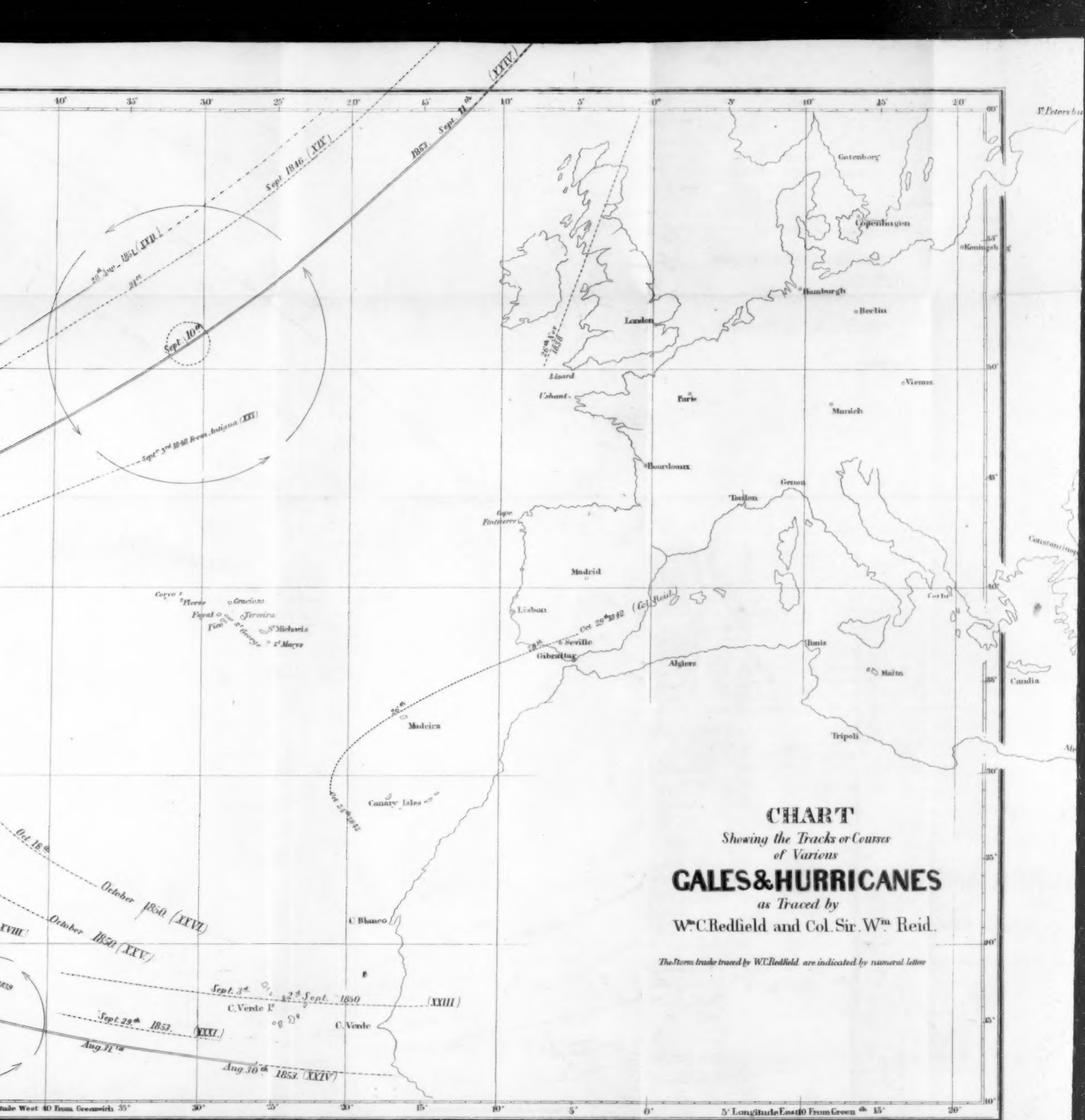

HUDSONS BAY
LABRADOR
Cape Farewell
Dec 1836 (XXVII)
Moose Fort
CANADA
NEWFOUNDLAND
ST LAWRENCE GULF
NOVA SCOTIA
Halifax
Sable
C Sable
Toronto
Boston
New York
Philadelphia
Baltimore
Washington
UNITED STATES
Chesapeake
Charleston
Natchez
New Orleans
Mobile
Pensacola
FLORIDA
TEXAS
MEXICO
Matamoras
Tampico
S Blas
Mexico
Vera Cruz
Acapulco
Honduras
Volcano of Guatimala
PACIFIC OCEAN
Bermuda
CUBA
JAMAICA
HAITI
Porto Rico
Barbadoes
Antigua
Guadaloupe
Dominica
St Lucia
Martinique
St Vincent
Grenada
Tobago
Trinidad
Caracas
Margarita
Cartagena
Gulf of Mexico
Sept. 1853. (XXX.)
26th September 1815. (XXX)
Capt Gummys hurricane 1828. XVIII
18th Oct 1780 called the great Hurricane (Col. Reid.)
Hurricane of August 1831
Sept 1839
Sept 1815
Oct 1780
Oct 14th
Oct 16th
Sept 1850. (XXVII)
1st Oct. 1850
Sept 1837. (XXI)
Oct 1846 (XX)
Sept 1837. (XXI)
Sept 1830. (VI)
Aug 1837. (XVI)
Sept 1837. (XXI)
Sept 1837. (XXI)
Aug 1837. (XVI)
Aug 1837. (XVI)
June 25th 1831. (I)
Dec 1780
Oct 1837. (XI)
Sept 1837. (XXI)
Sept 1837. (XXI)
Sept 1837. (XX

CHART
Showing the Tracks or Courses of Various
GALES & HURRICANES
as Traced by
Wm C. Redfield and Col. Sir. Wm Reid.
The Storm tracks traced by W.C. Redfield are indicated by numeral letters
Sept. 11th 1853 (XXIV)
Sept. 1846 (XIX)
Sept. 10th
Sept. 3rd 1846 from Antigua (XXI)
Oct. 29th 1842 (Col. Reid)
October 1850 (XXVI)
October 1850 (XXV)
Sept. 3d 1850 (XXIII)
Sept. 29th 1853 (XXXI)
Aug. 30th 1853. (XXIV)
Gothenburg
Copenhagen
Hamburgh
Berlin
London
Lizard
Ushant
Paris
Vienna
Munich
Bourdeaux
Genoa
Toulon
Cape Finisterre
Madrid
Lisbon
Seville
Gibraltar
Algiers
Tunis
Malta
Candia
Madeira
Tripoli
Canary Isles
C. Blanco
C. Verde I.s
C. Verde
Flores
Graciosa
Fayal
Terceira
Pico
St Michaels
St Marys
St Petersburgh
Constantinople
Longitude West from Greenwich
Longitude East from Greenwich



Engraved by W.S Barnard NY.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of Various
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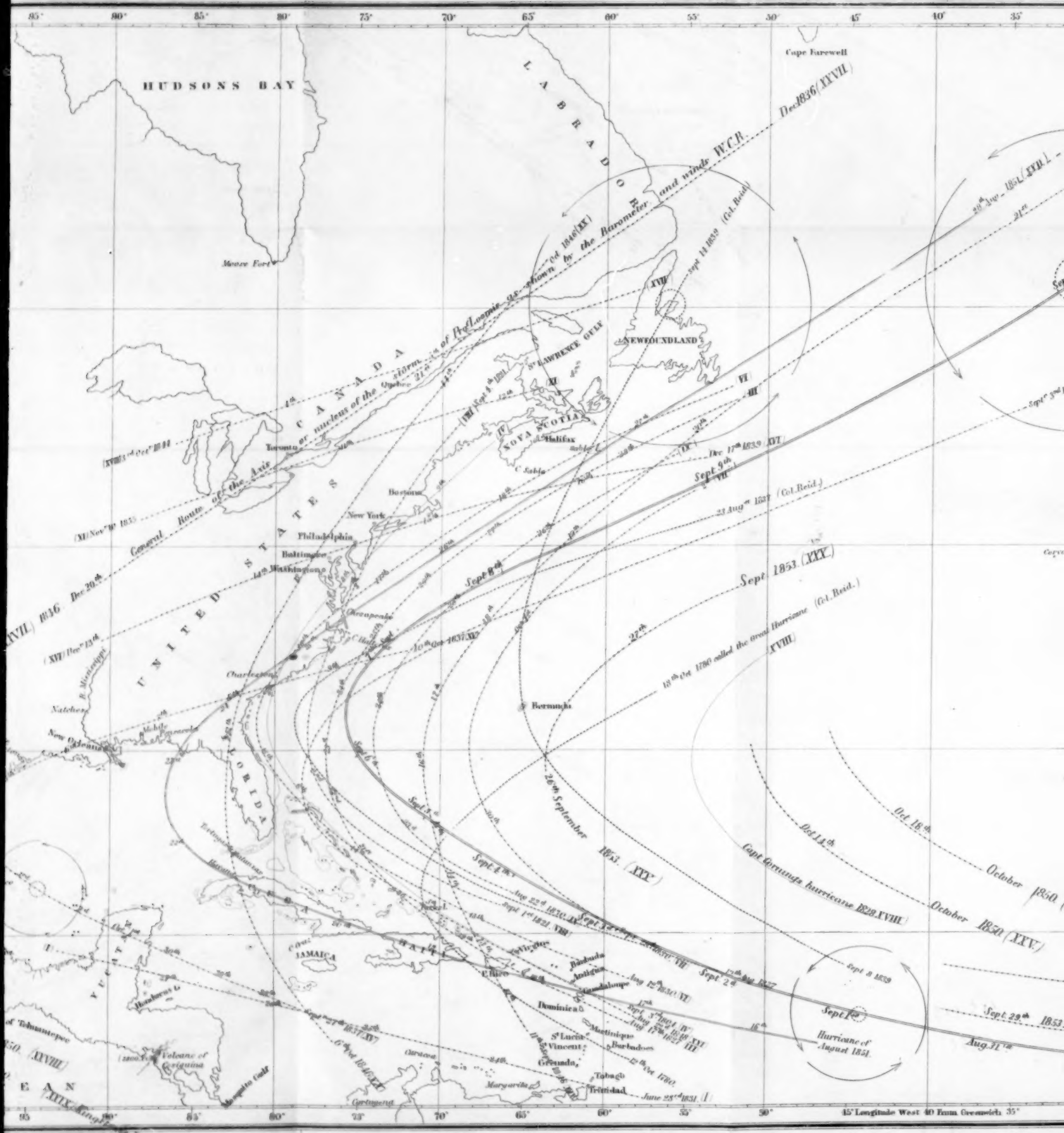
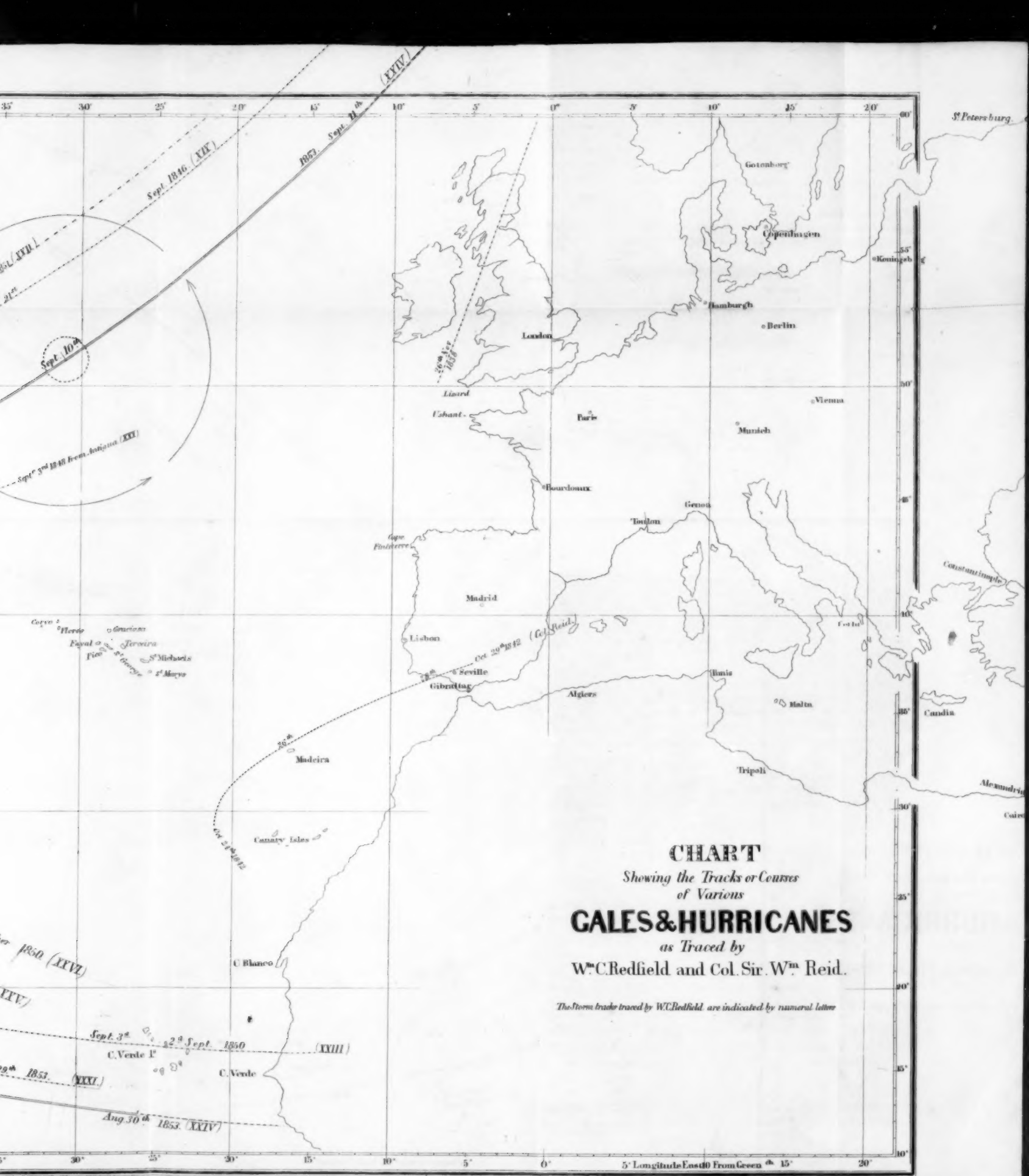
Sept. 1846 (XIX)
1853. Sept. 11th (XXIV)
Sept. 10th
Sept. 3rd 1846 from Antigua (XX)
Oct. 29th 1842 (Col. Reid)
October 1850 (XXVI)
October 1850 (XXV)
Sept. 3d 1850 (XXIII)
Sept. 29th 1853. (XXXI)
Aug. 31st
Aug. 30th 1853. (XXIV)
Lisbon
Seville
Gibraltar
Madeira
Canary Isles
C. Blanco
C. Verde I.
C. Verde
Algiers
Tunis
Malta
Tripoli
Candia
Constantinople
Genoa
Toulon
Marseilles
Paris
Vienna
Munich
Berlin
Hamburgh
Copenhagen
Gottenburg
St Petersburg
London
Lizard
Ushant
Bourdeaux
Madrid
Cape Finisterre
Corvo
Flores
Gracioza
Fayal
Pico
Terceira
St Michaels
St Marys
Longitude West 40 from Greenwich
Longitude East 40 From Green


HUDSONS BAY
Moose Fort
Cape Farewell
Dec 1836 (XXVII)
Oct 1846 (XX)
Sept 14 1839 (Col. Reid)
NEWFOUNDLAND
ST LAWRENCE GULF
CANADA
Toronto or nucleus of the storm
General Route of the Axis
NOVA SCOTIA
Halifax
C Sable
Dec 17th 1839 (XV)
Sept 9th
23 Aug 1837 (Col. Reid.)
Boston
New York
Philadelphia
Baltimore
Washington
UNITED STATES
Sept 1853 (XXV)
15th Oct 1780 called the Great Hurricane (Col. Reid.)
(XVIII)
Bermuda
Charleston
Natchez
New Orleans
Mobile
Pensacola
FLORIDA
26th September 1815 (XIV)
Capt Gerrings hurricane 1828 (XVIII)
October 1850 (XXV)
JAMAICA
Dominica
Martinique
Barbados
Antigua
Guadaloupe
St Lucia
St Vincent
Grenada
Tobago
Trinidad
Curacoa
Margarita
Cartagena
Mosquito Gulf
Volcano of Cotopaxi
Hurricane of August 1851
Aug 31st
Sept 29th 1853
June 23rd 1831
45° Longitude West 40 from Greenwich 35°



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